AUTOMOBILE ENGINEER

DESIGN · PRODUCTION · MATERIALS

Vol. 50 No. 3 MARCH 1960 PRICE: 3s. 6d.

INTRODUCING THE ECCO 40

A new, even better spray-gun developed from the highly successful ECCO 30

* Large air ducts and effective nozzle combinations for greater capacity
* New packing system for paint needle prevents leakage
* Ease of operation—comfortable pistol grip . . . long, two-finger trigger . . . single hand adjustment of fluid and fan controls
* Interchangeable paint and air connecting nipples
* Few parts simplify maintenance

Based on the highly successful Ecco 30, the Ecco 40 has even greater capacity and is easier to operate and maintain. The gun has a light, durable body of modern design and a range of nozzle combinations enabling it to be used for all spray-painting jobs.

USED DAILY AT JAGUARS!

All over the world, the name 'Jaguar' means performance and good looks. At their Coventry works—where craftsmanship is allied to modern production methods—Jaguar Cars Ltd., have introduced Ecco 40 guns to apply the finishes for which they are famous.

A COMPLETE RANGE OF COMPRESSED AIR EQUIPMENT

Atlas Copco manufactures portable and stationary compressors, rock-drilling equipment, loaders, pneumatic tools and paint-spraying equipment. Sold and serviced by companies and agents in ninety countries throughout the world.

Photograph by courtesy of Jaguar Cars Ltd.

Atlas Copco

PUTS COMPRESSED AIR TO WORK FOR THE WORLD

Contact your local company or agent or write to Atlas Copco AB, Stockholm 1, Sweden.

Good pull for car men!

Television is now an established and well-nigh indispensable advertising medium for the motor industry. It can play a vital role in your marketing plans, not only in the selling of cars by persuasively demonstrating your range in millions of homes, but also in swaying preferences, supporting your dealers, developing existing markets and expanding the new markets already being created by the new burst of British prosperity.

Associated-Rediffusion will be pleased to show you specimen campaign budgets together with interesting facts about your potential market viewing audience. Just contact Eric Laman (Holborn 7888) for full details.

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KIRKSTALL AXLES

ON THE

A.E.C.

18 CUBIC YARD DUMPTRUK

KIRKSTALL FORGE ENGINEERING LIMITED LEEDS, 5

Telephone : Horsforth 2821

On the road in Swedish Lapland some of the test cars meet typical Arctic winter conditions. In weather like this, starting was easier and warm-up more rapid with BP 'Visco-static' motor oil.

LAPLAND TEST PROVES EASIER STARTING WITH BP ENERGOL 'VISCO-STATIC'*

the oil that's proved to give 80% less piston ring wear

ARCTIC SWEDEN – home of reindeer and Laplanders – this was where BP scientists chose to carry out cold performance tests with fuels and motor oils.

Here in the intense winter cold of the Arctic, engineers made many tests on a number of different cars. In every case where BP 'Visco-static' motor oil was used, tests proved quicker warm-up compared with a winter grade ordinary oil SAE 20. They found too that starting in the intense cold, which went as low as minus 10 degrees Fahrenheit, was consistently easier with BP 'Visco-static'.

Flows freely even in intense cold

Even in freezing cold, BP 'Visco-static' remains free-flowing. So your engine is free to turn over more easily. This means easier, quicker starting and less strain on your battery.

From the moment your engine starts it runs more easily, takes less time to warm up and gives better performance. You save petrol too because less power is lost in oil drag with BP 'Visco-static'.

80% less wear in tests

Because it flows more freely in cold weather BP 'Visco-static' prevents the heavy wear that usually occurs immediately after cold starting. Tests in the laboratory and on the road with the amazing radio-active wear detector showed 80% less wear on piston rings compared with ordinary oils.

Change now

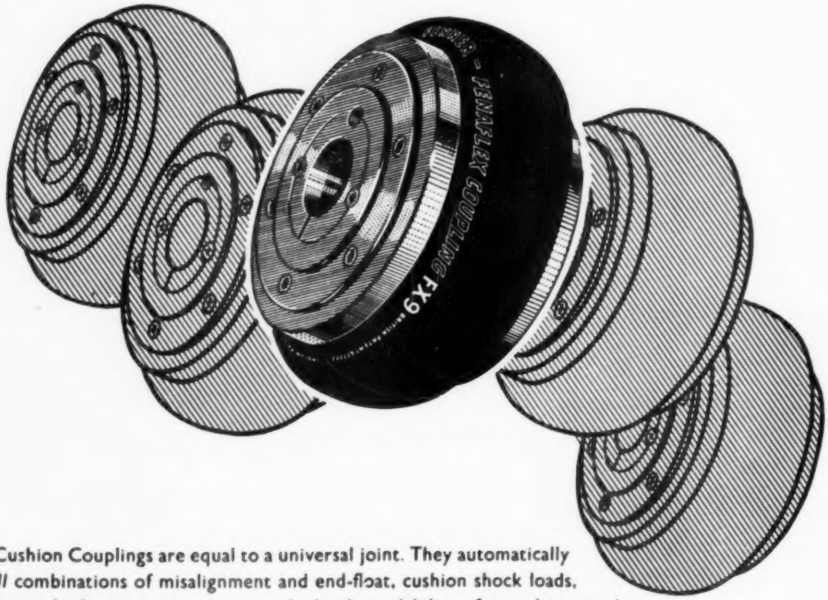
With BP 'Visco-static' your car starts more easily, gives better performance and will last longer. So change now. But remember for best results you should make a complete change – have your old oil drained away and replaced with BP 'Visco-static'.

*'VISCO-STATIC' IS A TRADE-MARK OF THE BRITISH PETROLEUM COMPANY LIMITED

BP

FENAFLEX

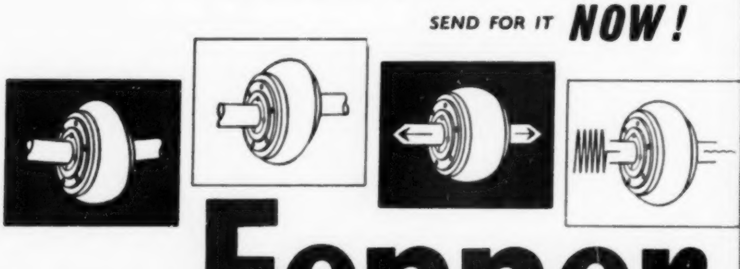
CUSHION COUPLINGS



THE RUBBER TYRE COUPLINGS WITH THE FOUR-WAY FLEX

Fenaflex Cushion Couplings are equal to a universal joint. They automatically correct *all* combinations of misalignment and end-float, cushion shock loads, reduce torsional vibration, yet operate with the dependability of a modern tyre!
The Fenaflex Coupling *is* a tyre with synthetic tension members bonded in rubber. Depending on the size of the coupling and the duration of shaft misplacement, it corrects angular misalignment up to 4°, parallel misalignment up to $^1/_8$ inch and end-float up to $^5/_{16}$ inch. There is no metal-to-metal contact, lubricating is unnecessary and there are no protruding parts.
This coupling occupies the minimum space on the shaft and Fenner standard Taper-Lock bushes make mounting quick and easy. As the flexible member is moulded with a transverse split, it can be replaced without moving the machine or the motor.
This flexible coupling with time-saving TAPER-LOCK for fixing, is available in 9 sizes, the largest taking 20 h.p. per 100 r.p.m.
Leaflet 353/18 will give you full technical information.

SEND FOR IT **NOW!**



Fenner

J. H. FENNER & CO. LTD · MARFLEET · HULL

Fenaflex Couplings are obtainable from stock at all 19 Fenner branches and Fenner engineers will gladly demonstrate Fenaflex to you—telephone your nearest branch.

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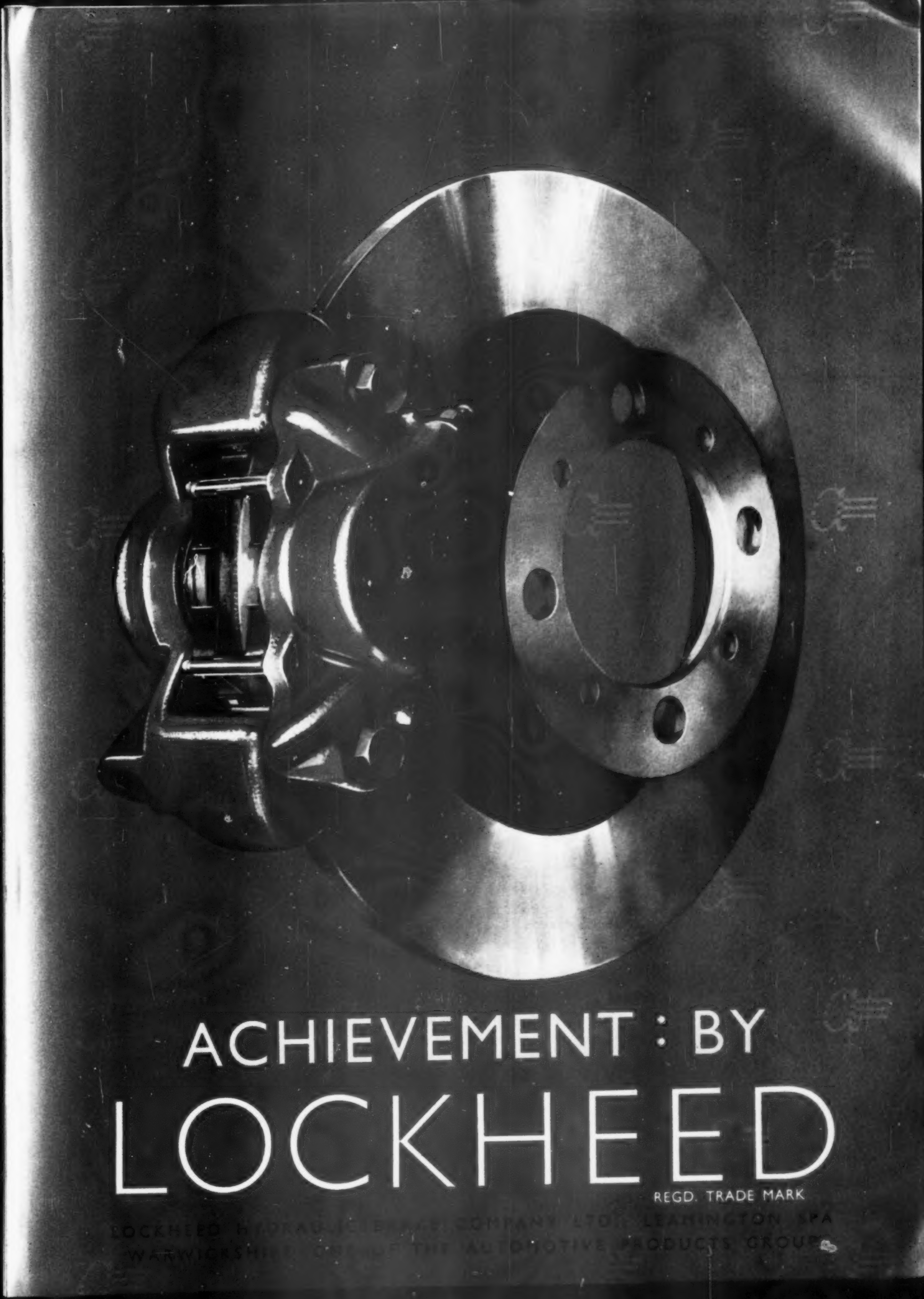
LARGEST MAKERS OF V-BELT DRIVES IN THE COMMONWEALTH


ACHIEVEMENT : BY
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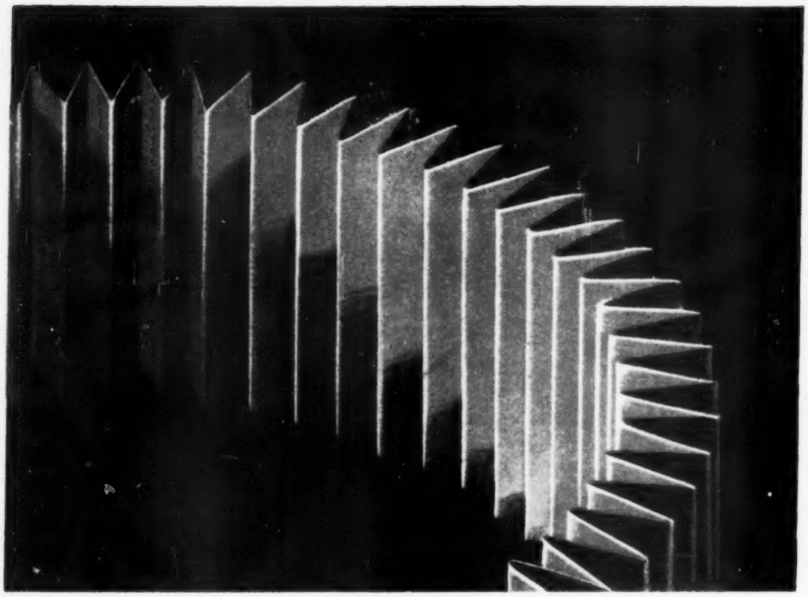
REGD. TRADE MARK



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IN PARTICULAR, THE PURC

MAXIMUM FILTRATION EFFICIENCY: Almost 100% of all abrasive dust is removed by the 'Micronic' filter including particles small enough to be measured in microns; engine life is greatly extended.

EFFICIENCY AT ALL SPEEDS: Dry-type filters act efficiently at all speeds, some other types do not.

ENGINE EFFICIENCY UNAFFECTED: Only *dry-type* air filters present negligible resistance to air flow.

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EASIER MAINTENANCE: The element can be cleaned by tapping or by blowing through with compressed air; or it can be renewed in seconds without mess or trouble.

REGD. TRADE MARKS: PUROLATOR, "MICRONIC"

PUROLATOR 'MICRONIC' FILTERS HAVE
PROVED THEIR OUTSTANDING SUPERIORITY
FOR THE FULL-FLOW FILTRATION
OF LUBRICATING OIL, AND THE
FILTRATION OF FUEL OIL.

y-type AIR FILTER

LATOR 'MICRONIC' FILTER

GREATER RELIABILITY: The Purolator air-filter will not permit dirty air to enter the engine in any circumstances.

INEXPENSIVE TO BUY AND TO SERVICE

CONFORMS TO BRITISH STANDARDS

FOR A WIDE RANGE OF APPLICATIONS
Purolator 'Micronic' dry-type air filters are available in a variety of sizes and shapes to suit most applications.

AUTOMOTIVE PRODUCTS COMPANY LIMITED
LEAMINGTON SPA, WARWICKSHIRE, ENGLAND

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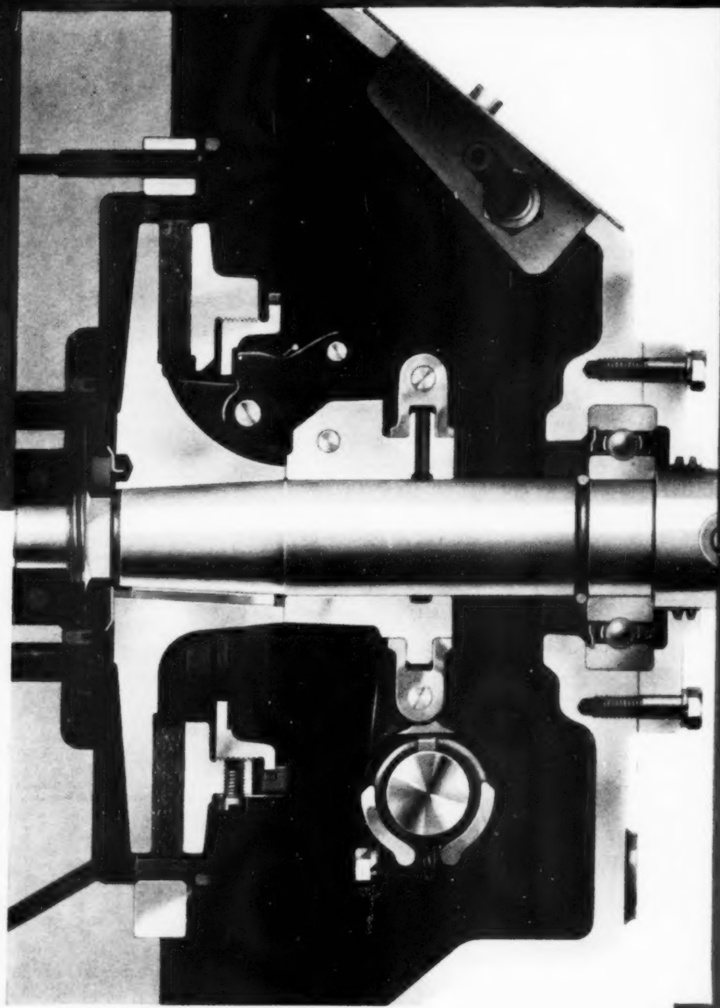

The 7½" Rockford power take-off

FOR THE SMALLER ENGINE

This is an addition to the range of Rockford over-centre clutches and power take-offs, for use with the smaller engine.

The clutch operates in the well-proved and successful Rockford manner, the toothed facing segments are driven by an internally-toothed drive ring bolted to the flywheel, and lie between a fixed pressure-plate on the driven shaft and the moving toggle-operated pressure plate. The latter carries a threaded adjusting ring, held after adjustment by engagement of its castellations with a clicker spring. This arrangement gives a fine and accurate adjustment, bringing out the full advantages of the over-centre operation.

The release bearing—which, as in all Rockford clutches, is loaded only during the moments of engagement and disengagement—is of bronze, riding on the release sleeve and lubricated from a nipple on the clutch housing.

SUMMARY OF FEATURES

(A) Robust construction giving great durability.

(B) Simple adjustment without the aid of special tools.

(C) Provision on clutch housing for attachment of reduction gearbox.

(D) Easy to service — new facing segments are quickly fitted.

ROCKFORD

CLUTCHES AND POWER TAKE-OFFS

BORG & BECK COMPANY LIMITED

Specialists in the transmission of power.

LEAMINGTON SPA, WARWICKSHIRE ENGLAND

Regd. Trade Mark: Borg & Beck

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for machining either . . .

. . . forged dies used in the manufacture of aircraft and automobile components

. . . one, two or three components from rough forged billets at one setting

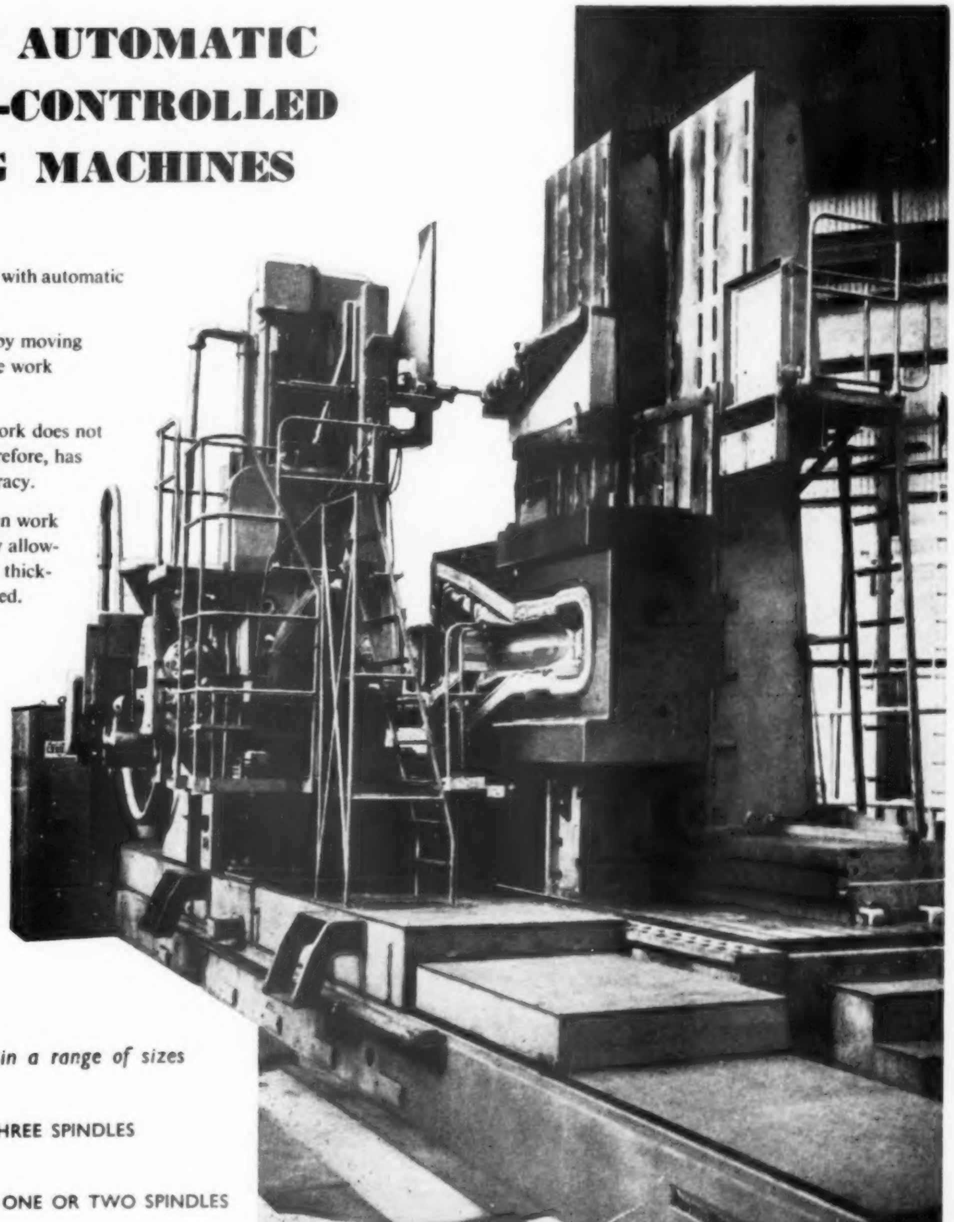
KELLER AUTOMATIC TRACER-CONTROLLED MILLING MACHINES

Powerful machines fitted with automatic electric controls.

Cutting action obtained by moving the machine elements, the work being held stationary.

The size and weight of work does not cause deflection and, therefore, has no effect on cutting accuracy.

No fixed distance between work table and spindle, thereby allowing a wide range of work thicknesses to be accommodated.



A Keller BG-22 Machine installed in the Forging Division of High Duty Alloys Limited, Redditch. This set-up shows the machining of a die for producing part of an aeroplane undercarriage component. The die blocks used for the forging of this component are of alloy steel and weigh 43 tons unmachined.

Three types available in a range of sizes

TYPE B.L.
30" × 20" ONE OR THREE SPINDLES

TYPE B.G.21
5'×2½', 6'×4' & 8'×4' ONE OR TWO SPINDLES

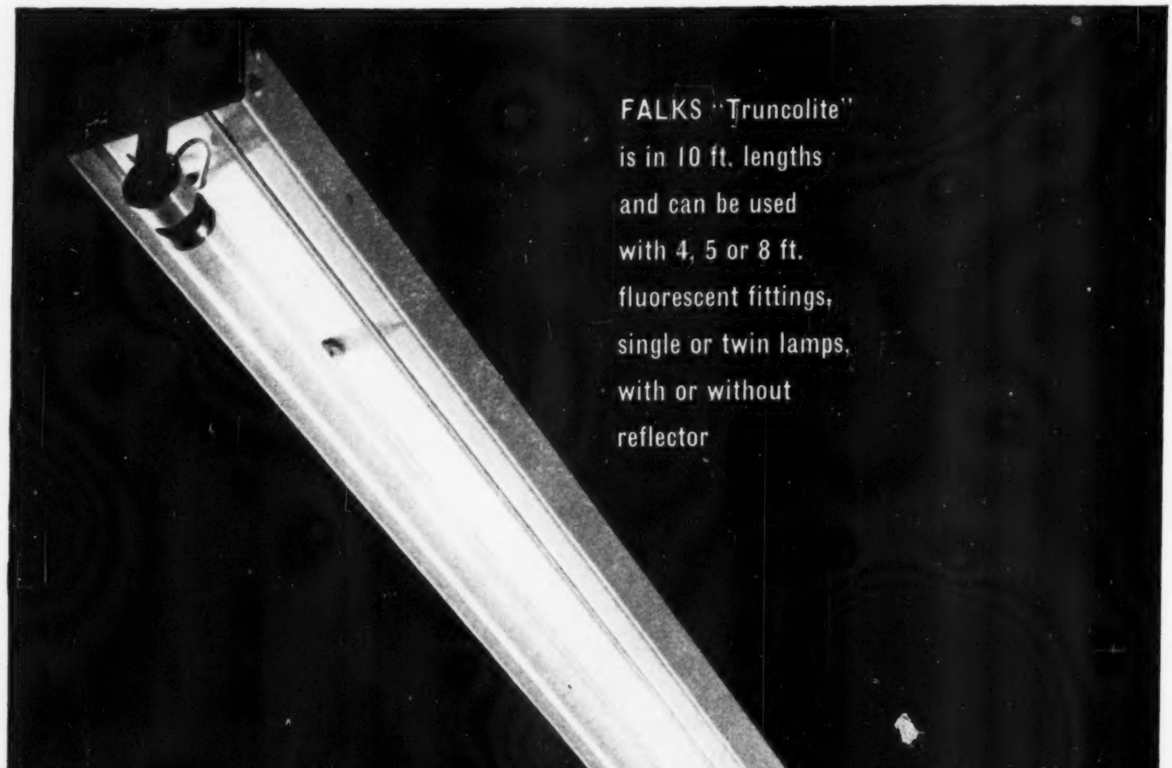
TYPE B.G.22
10'×5', 12'×6' & 14'×7' ONE OR THREE SPINDLES

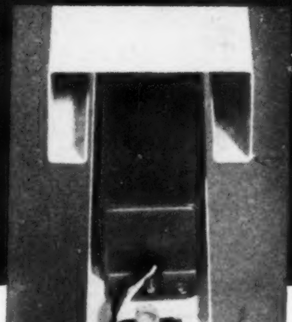
Sole Agents :—

ALFRED HERBERT LTD., COVENTRY *Factored Division, Red Lane Works.*

AH

AD. 353





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FALKS, the long established lighting specialists, designers and manufacturers of all types of fittings. Lighting Engineering Services freely available.

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FALK, STADELMANN & CO. LTD

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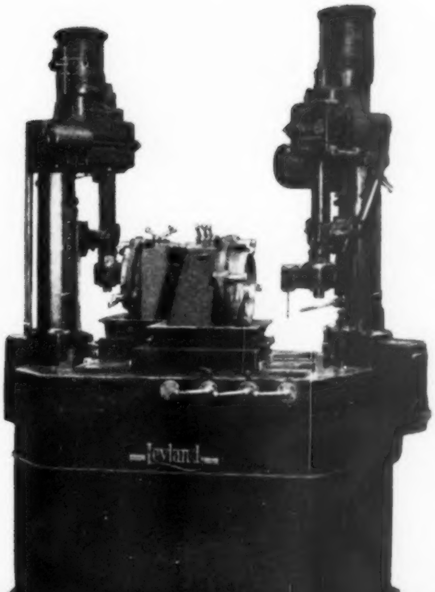
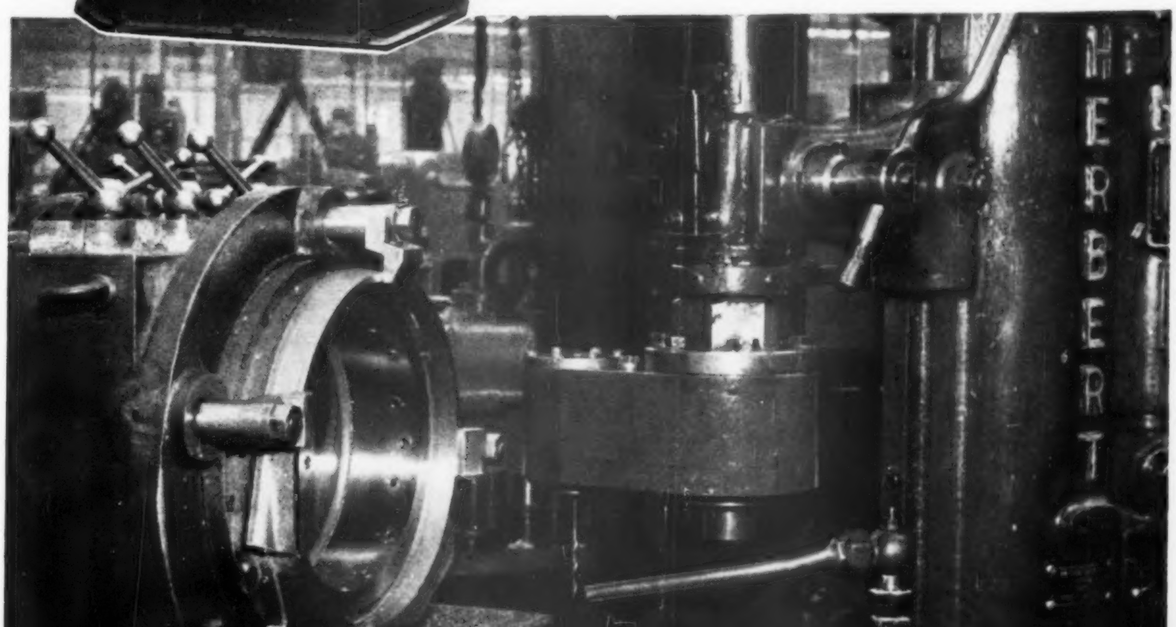


— assembled to customers' drilling requirements

Herbert All-electric Drilling Machines are made in nine types for drilling holes from the very smallest, at 18,000 r.p.m. up to 1¼″ diameter.

This equipment meets all general purpose requirements. Unit construction and interchangeability enables special requirements to be easily met.

We will quote for machines and equipment to meet special requirements for drilling, tapping and associated operations.



Leyland Motors Ltd. use two Herbert Type C top columns on a common base equipped with duplicate fixtures for high production drilling of nineteen $\frac{11}{16}$″ diameter rivet holes in external brake bands. There are three series of holes in each band.

ALFRED **HERBERT** LTD., COVENTRY

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where it matters ......

..... in the LAND-ROVER

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- Rear Axle Shaft (R.H.)
- Rear Axle Shaft (L.H.)
- Differential Pinion
- First Speed Layshaft Pinion
- Reverse Cluster
- Differential Pinion Spindle
- Reverse Wheel Shaft
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....they specify steels by

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ALLOY STEELMAKERS · FORGEMASTERS · STEEL FOUNDERS · HEAVY ENGINEERS

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...and ends with **FERODO**

Anti-Fade Brake Linings

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FERODO LIMITED · CHAPEL-EN-LE-FRITH   A Member of the Turner & Newall Organisation

New ACTARC MODULA

Another reliable transformer for REPAIR and PRODUCTION WELDING

Ten Star Features

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- ★ LOW MAINS INTAKE
- ★ TWO CURRENT RANGES
  30-250 AMPS. AT 50 VOLTS
  40-185 AMPS. AT 80 VOLTS
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- ★ ALL CONTACTS FULLY IMMERSED IN OIL

Range of ACTARC Transformers.

Air and Oil cooled MEDIA transformers ...	Low Voltage range	65 V	50-310 A
	High Voltage range	95 V	40-220 A
Oil cooled MASTA transformer	Low Voltage range	65 V	70-440 A
	High Voltage range	95 V	50-300 A
Air cooled MONTA transformer	Low Voltage range	50 V	30-200 A
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	Two easily selected infinitely variable current ranges.		
Oil cooled MODULA (Tapped Choke) ...	Low Voltage range	50 V	30-250 A
	High Voltage range	80 V	40-185 A

Suitable for electrodes of the lime-ferritic and deep penetrating types and other special electrodes requiring high striking voltages.
All transformers can be supplied for standard voltage supplies for connection to single or 3-phase. 50 cycle A.C. systems.
Special models available for other voltages and frequencies.

ELECTRODES
A wide range of Actarc electrodes is available. There are lime-ferritic electrodes for welding medium carbon and low alloyed steel; mild steel electrodes for general purpose work; special rods for vertical and overhead welding, and for deep penetration; electrodes for fast horizontal production work; electrodes for boiler plate; non-ferrous electrodes for aluminium, nickel and bronze.

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P 11

JOHN BULL

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Difficult shapes are welcome. With [illegible] in design and manufacture, we [illegible] the most complicated boots and gaiters [illegible] exactly the right rubber [illegible] maximum resistance to oil, [illegible] extremes of temperature. [illegible] the design of components.

In addition to Boots and [illegible] include Convoluted Hose, [illegible] Mouldings.

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Bellofram *Seals are long stroke, deep convolution, constant area diaphragms, which are free positioning with complete relaxation within their stroke. Bellofram Seals are responsive to small pressure changes, have virtually no mechanical spring gradient and possess extremely long flex life.*

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Seals

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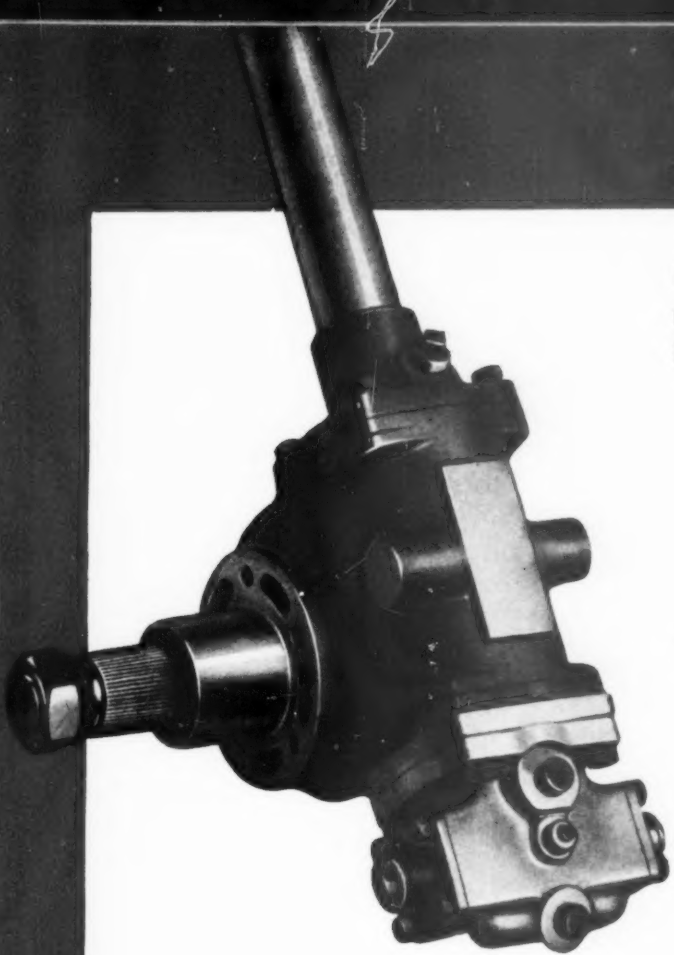

Interchangeable, on the same mounting, with the standard Marles manual gear unit.

THE TYPE 3 'UNIVERSAL' UNIT

Illustrated above is the Type 3 'Universal' steering gear which incorporates the hydraulic control valves mounted upon our type '861' manual gear. This is for use with a separate power pump and with power cylinders operating on the steering linkage. Further particulars will be sent on request.

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IN EVERY INGOT . . .
. . . cast from the furnaces of the *Osborn* group of Companies, cumulative experience from generations of craftsmanship is combined with modern research and technology to produce steel of superlative quality. A wide range of high-speed and other special tool steels is manufactured and many other products including steel castings, forgings and engineers' cutting tools are produced within the same organisation.
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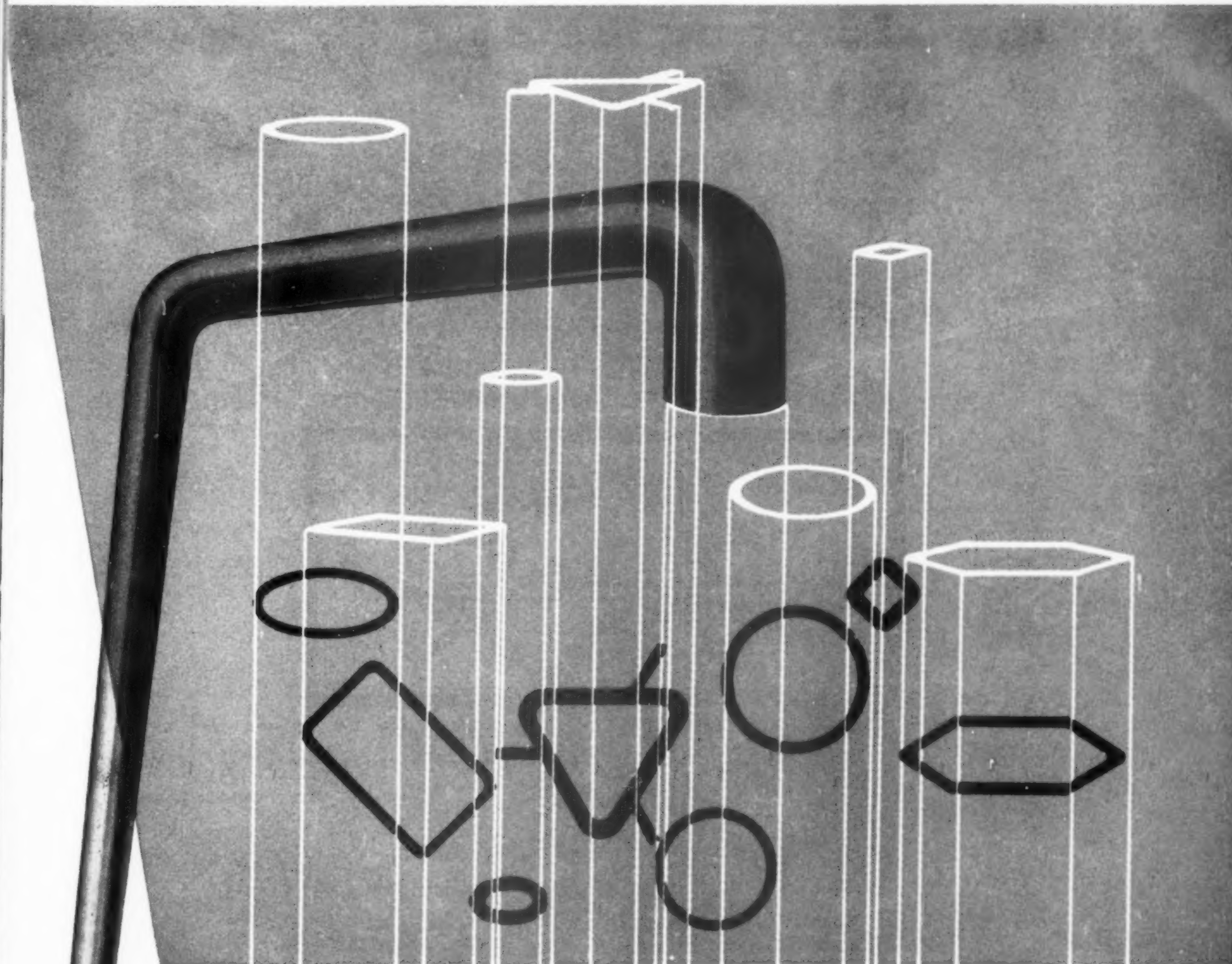
Is manipulation critical?



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Loss of temper in tubes, and of tempers in boardrooms, have both become rarer since H.D.A. evolved Hiduminium 1C, 14, 22, 42 and 46—alloys specially developed by them for easy manipulation. Drawn tubes and hollow extruded sections made from these alloys are not only easy to manipulate: they retain their strength and smooth surface finish, as well as their weldability and excellent resistance to corrosion. Manipulation is only one of the problems associated with tube and hollow sections; but H.D.A. have all the technical knowledge and skill that the subject calls for—freely available on request.

Hiduminium

makes the most of

Aluminium

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For the brilliance that lasts and lasts . . .

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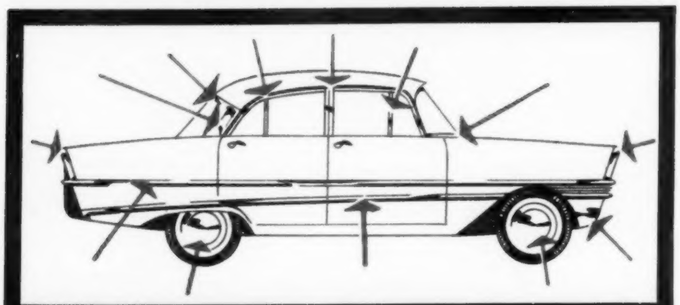
Stainless Steel

the car trim of to-day and of the future

THE MOTORIST says:

Trubrite keeps its beauty so much longer than other trim materials, and saves me work in cleaning. It resists scratches, never corrodes, and maintains the value of my car.



THE DEALER says:

Trubrite, with its time-proof brilliance, strength, and easy maintenance, makes an instant appeal in the showroom. It also helps me clinch those vital marginal sales.

Sparkling beauty enhances styling of modern cars
Cannot rust, peel or chip. No pitting.
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Bright right through.
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Already adopted for many parts both outside and in by leading manufacturers, such as Vauxhall, Morris, Wolseley, Riley, etc.

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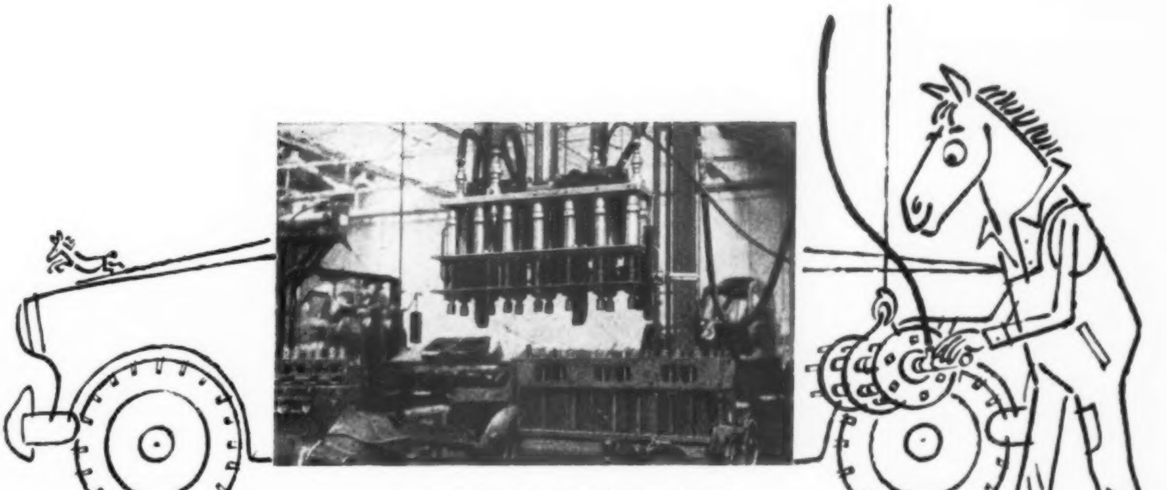
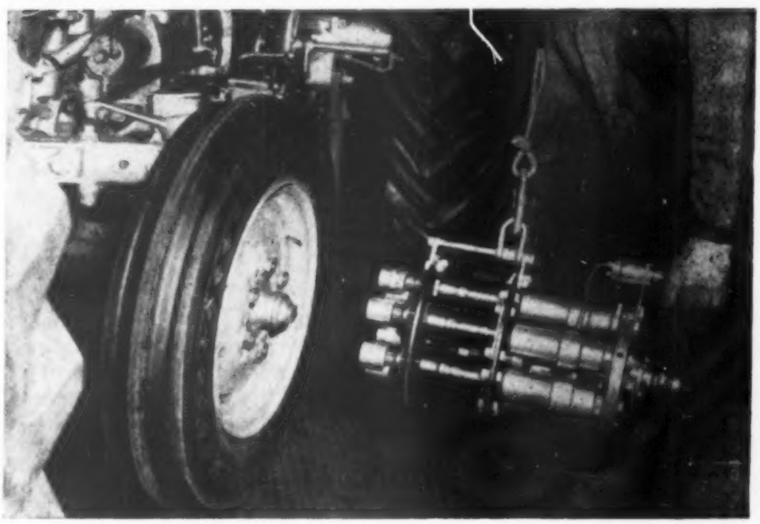


Assembling diesel engine cylinder heads with a 14-motor Desoutter nutrunner at the new Bedford vehicle plant at Dunstable.
Photograph by courtesy of Vauxhall Motors Ltd.

Desoutter in the Motor Industry

Without Desoutter power tools there would be no mass production. You may disagree, but that's *our* story and *we're* sticking to it. Come to think of it, do you know anything as fast, as reliable, as *non-stop* as a Desoutter power tool? Neither do we.

Our range of pneumatic and electric tools is nothing if not wide. But should you find a gap, we'll do our best to fill it for you. In certain cases we're prepared to produce an entirely new tool for a specific job. Write today for further details of Desoutter tools for the motor industry.



A six-motor multiple nutrunner used on the wheel assembly of Ferguson tractors.
Photograph by courtesy of Standard Motors Ltd.

Desoutter pneumatic and electric tools put power into your hands

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CBC300

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TECALEMIT—LUBRICATION, of course. You see the Tecalemit target and arrow sign and take the car in for lubrication service. Grease pumps, pipes, lifts, oil dispensers, air compressors—everything's Tecalemit, right down to the grease nipples.
So it's simple: Tecalemit stands for Lubrication.

But Tecalemit stands for filtration
In spite of high compressions, greater loadings and higher speeds, modern car engine bearings can tolerate almost anything—anything except foreign bodies in their oil. Thus the Tec-element: an oil filter element of astonishing efficiency. Most leading British engine manufacturers fit Tecalemit oil filters and so recommend Tec-elements as replacements. Sound advice!

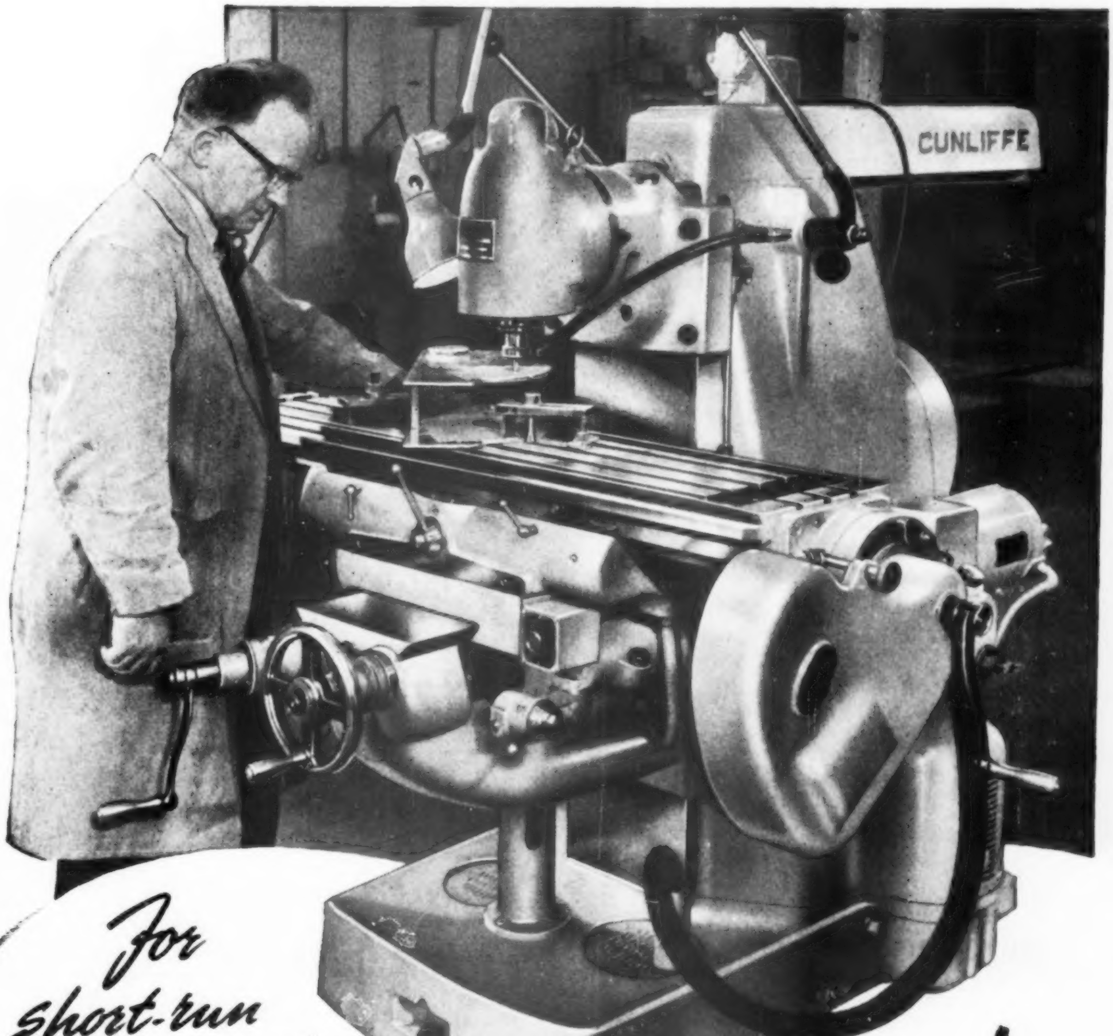
But Tecalemit make precision nylon piping too
Nylon piping for automotive uses was once merely a Good Idea. If only you could use it, it would be cheap, vibration resistant, strong, supple, chemically inert and so on. But how could it be produced to precision limits? Tecalemit found the answer—a resounding and exclusive technical triumph. Nowadays such great names as Austin, Aston-Martin, Ford, Jaguar and Rover use a great deal of Tecalemit extruded nylon piping for fuel lines and vent pipes.

But Tecalemit are famous for oil firing
Oil firing: it takes you out of the automotive field and into the brickworks and kilns. Much tidier brickworks, of course: no heaps of coal and slag. Just pipe runs, control panels, high efficiency and low cost. Oil firing is becoming a major industry in itself—and Tecalemit one of its most prominent names.

But Tecalemit make a thousand other things
Grease guns, power pumps, hose reels, lifts, sprayers, washing units . . . automatic and multiple lubricating systems for machinery and vehicle chassis . . . air cleaners, breathers and ribbon elements (finest air filtration at lowest cost) . . . in fact, an amazing number of things that help keep industrial and automotive machinery washed, pressured, connected, controlled, raised, lowered, filtered.
Oh yes—and lubricated. For of course Tecalemit stands for lubrication.

TECALEMIT **the Authority on Lubrication**

Tecalemit Limited · Plymouth · Devon



For short-run high production jobs or . .

. . . . or for prototype work as shown, CUNLIFFE & CROOM horizontals, with their in-built features of precision and rigidity, mean increased efficiency wherever they are installed. At the Imperial Tobacco Co., Ltd., Bristol, for instance, this machine, with vertical milling attachment, is fully employed in the Prototype Development Dept., on components for new machines.
CUNLIFFE & CROOM milling machines, horizontal, universal and vertical, are available in a range of sizes to reduce costs on your own work. Complete catalogues available. Write for your copies to-day.

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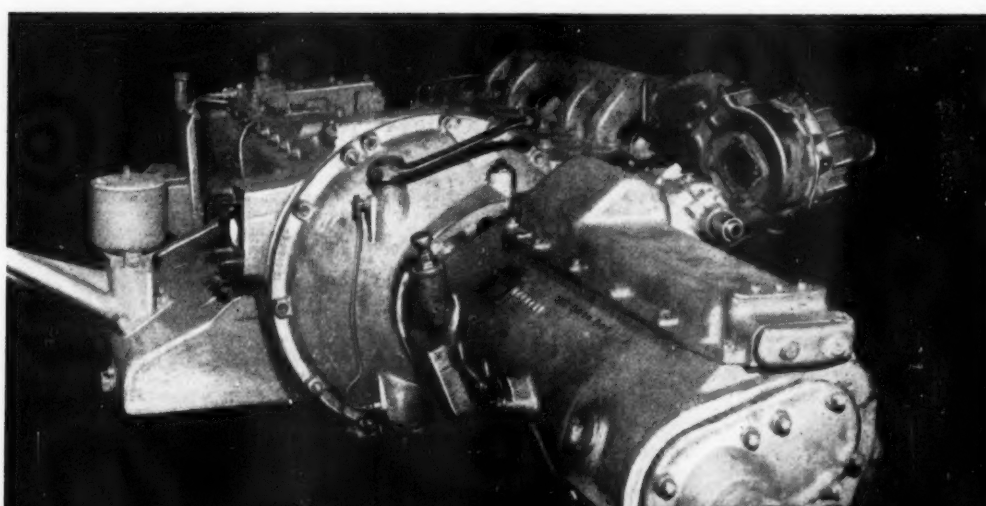
TO BUILD THEIR SPECIAL B.M.M.O. D.B.5. CONSTANT MESH



GEAR BOX FOR THEIR HIGH SPEED COACH SERVICE ON THE M.1.

David Brown are proud to have been entrusted with the production of the five-speed overdrive-top constant mesh gear box for the CM.5 — probably the most modern example of high speed passenger vehicle in regular service in Europe, if not the world.

DAVID BROWN

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AUTOMATIC SIZING INTERNAL GRINDING MACHINE

Finishing Jet Engine Bearings

at

FISCHER BEARINGS CO LTD
WOLVERHAMPTON

CHURCHILL automatic sizing internal grinding machines are renowned for their accuracy and speed of production, and our illustration shows one of a battery of Model H B M grinders engaged on jet engine bearings at Fischer Bearings Co. Ltd., Wolverhampton.

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- Single or double automatic operation cycle.
- Plunge cut or traverse grinding.
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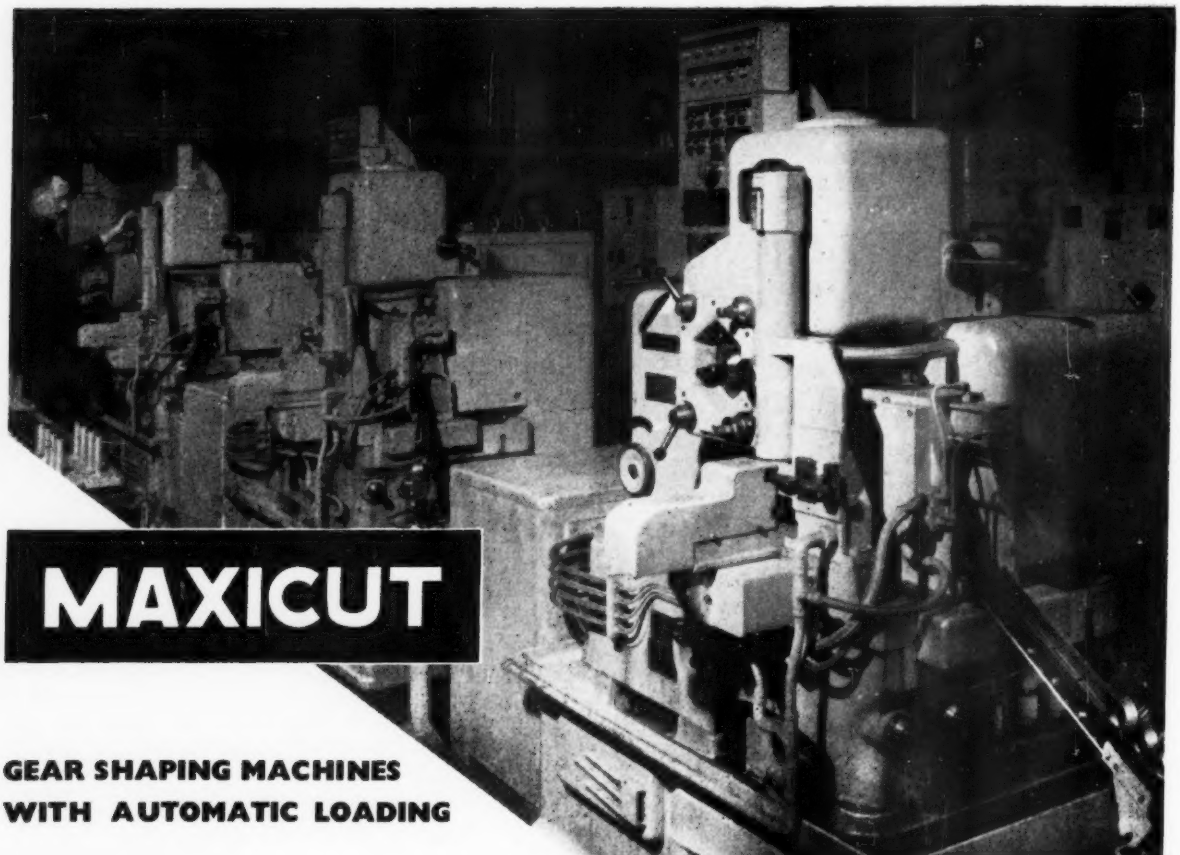

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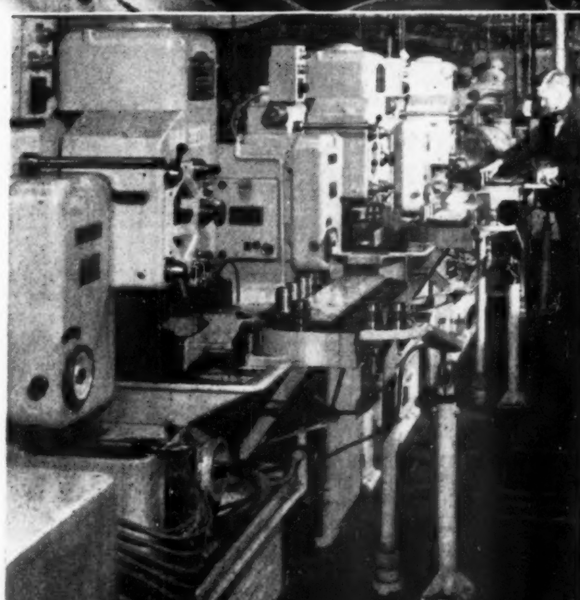
WITH AUTOMATIC LOADING



for mass production of automobile gears

These illustrations show two lines of Drummond No. 2A Maxicut Gear Shapers at the Austin Motor Co. Ltd., Birmingham. Machines in the top view are equipped with magazine loading and in the bottom illustration swinging arm type loaders are fitted.

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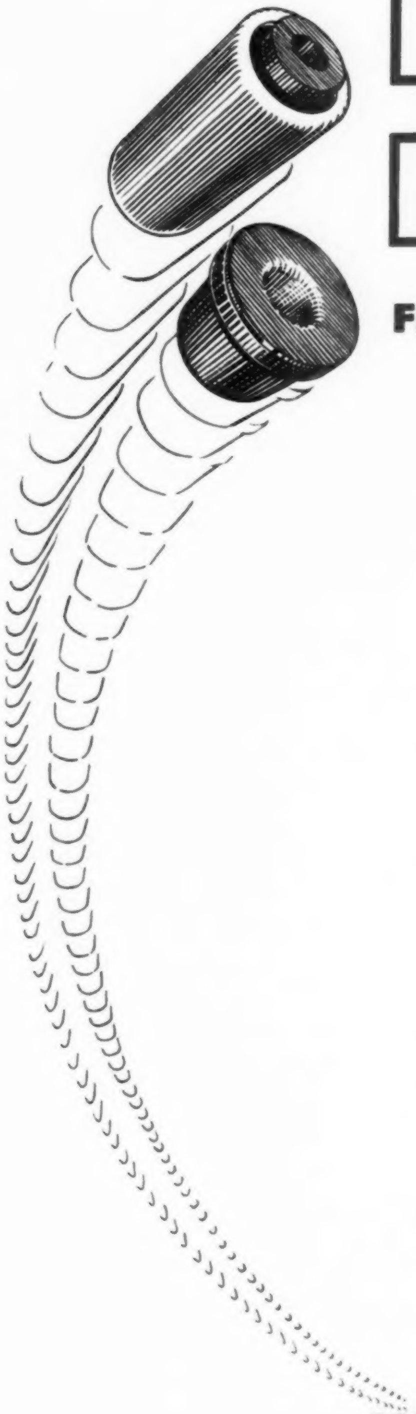

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For further information concerning these products please ask for the appropriate technical literature.

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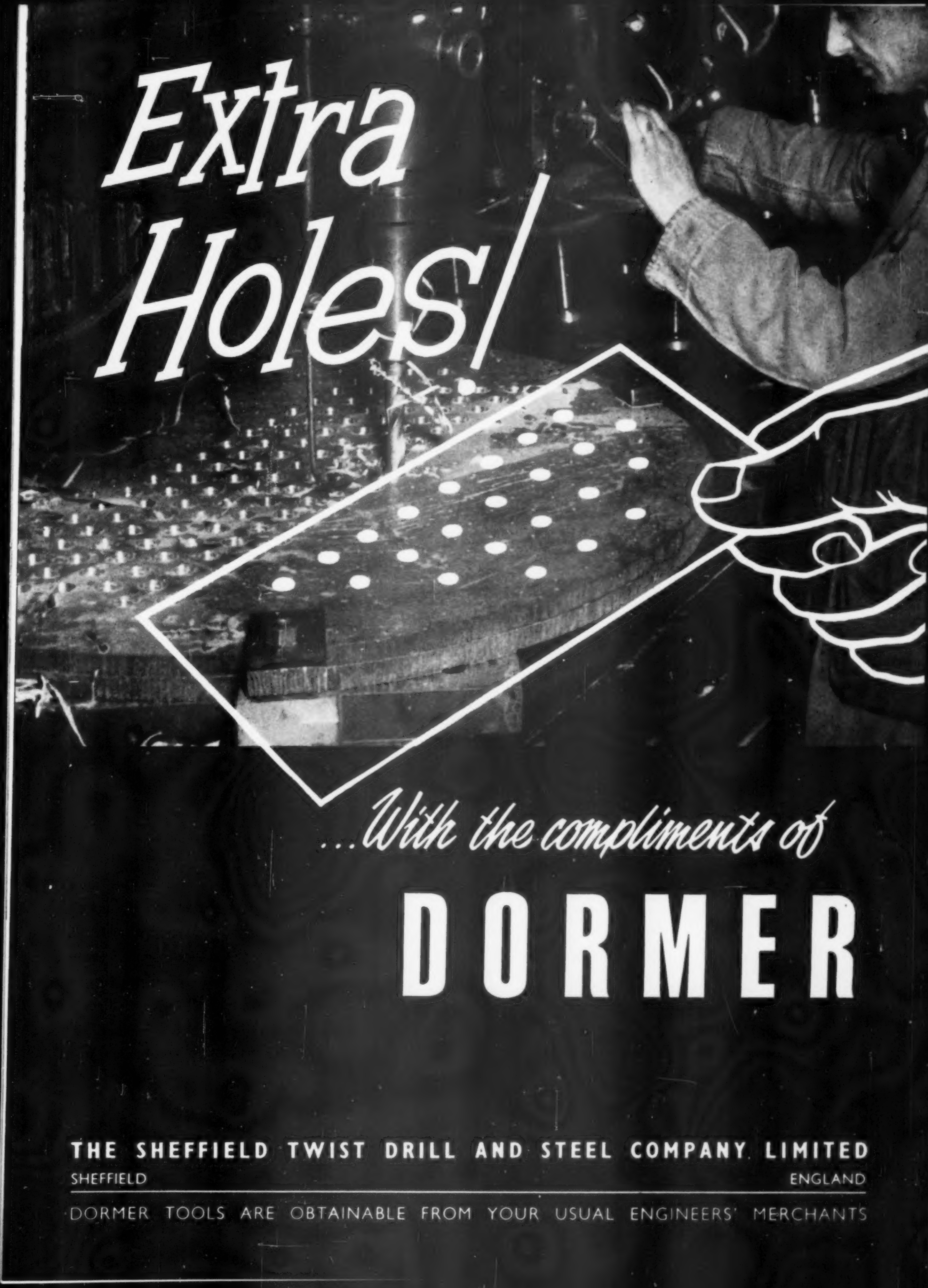
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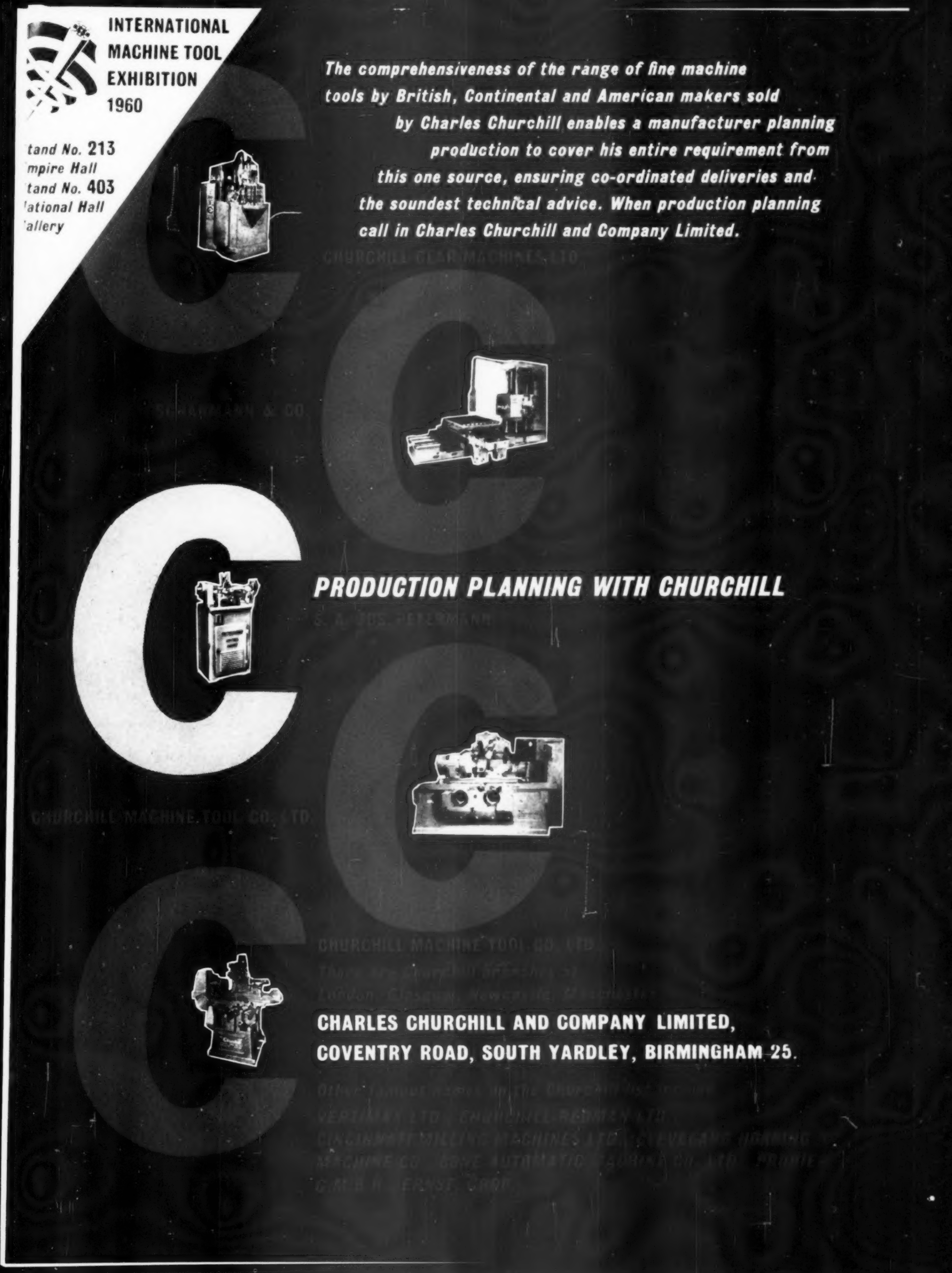
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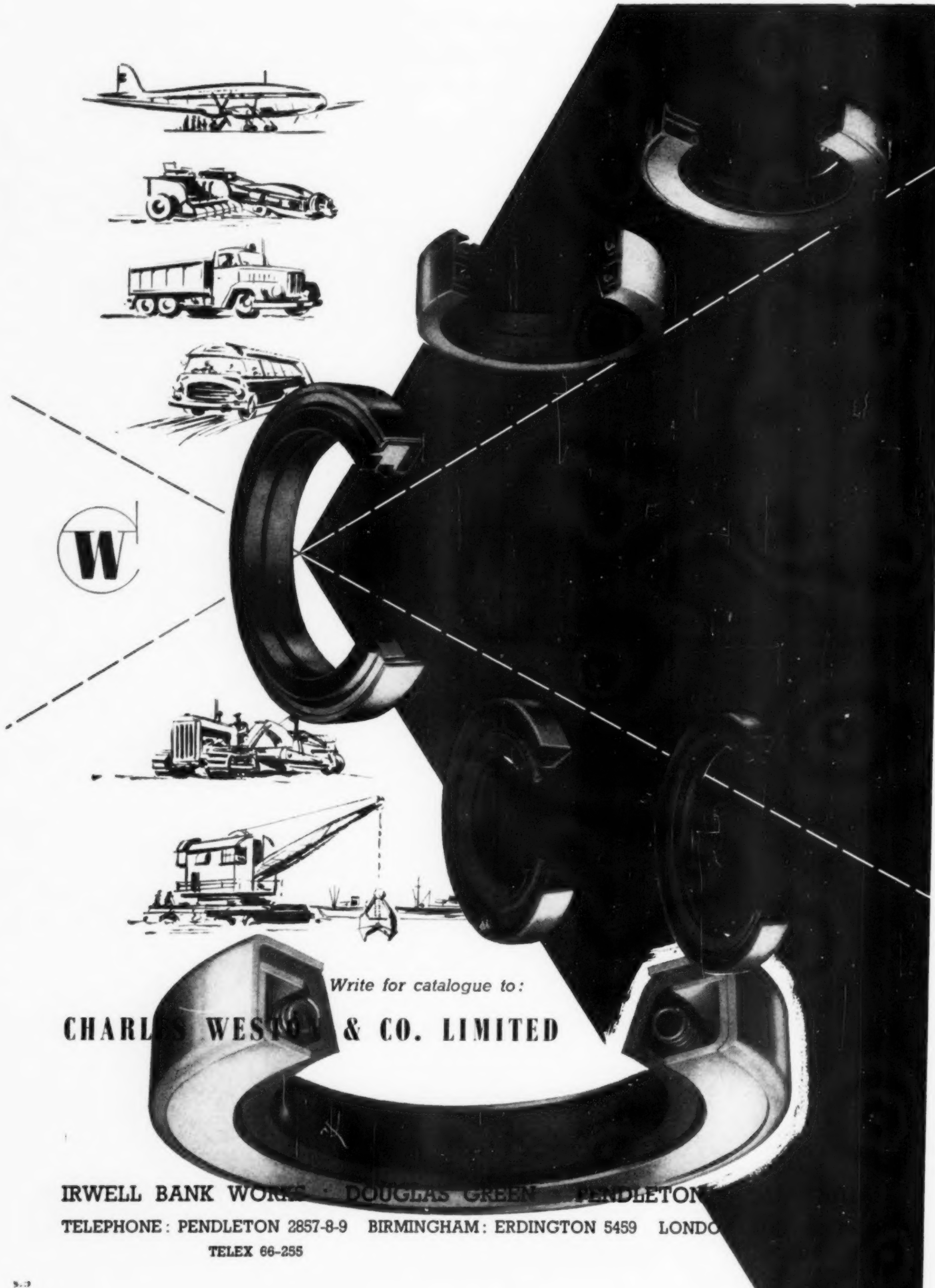

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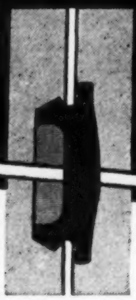
A new Grommet development

THE DOUBLE SEALING EMPIRE RUBBER GROMMET



infinitely accommodating in use: considerably reduces range of sizes because the same grommet can be used with several plate thicknesses or cable sizes

This newly developed self-conforming grommet, because it is immediately self-locking against the elements, is the solution to many of an engineer's sealing problems.
Any one size will not only accommodate itself to a variety of mounting plate thicknesses, but (designed for cable or control rod) will take these in a variety of sizes and be weather-, water- and dust-proof at a variety of angles to the cable or rod.

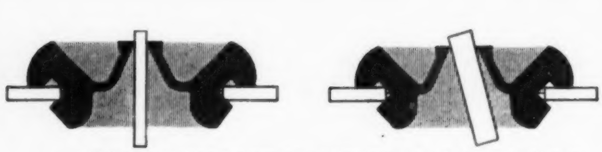
Because of its capacity to conform to many varying requirements, it enables a workshop stock range of grommets to be reduced to perhaps one tenth of that at present maintained.

THE NEW BLIND GROMMET | THE NEW DESIGNED GROMMET

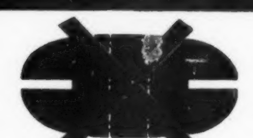
FREE | FREE | FITTED

Note how when sprung into position the grommet provides a perfect double seal by its own permanent pressures. The angled groove also creates a tight pressure hold on the metal plate.

In the cable grommet variety the same double pressure seal is created, allied to tight seal on various diameters of cable. This new grommet gives sound sealing at *all* vital points.



A useful feature of this cable grommet is that by reason of the designed taper of the cable entry and the flexibility of the web, a considerable angle of cable entry and a variety of cable size are possible. This avoids necessity for special grommets with angled bores.



In the conventional grommet, only one thickness of plate and only one size of cable can be accommodated. No effective seal is afforded by the parallel groove.

Now being produced in a range of sizes.

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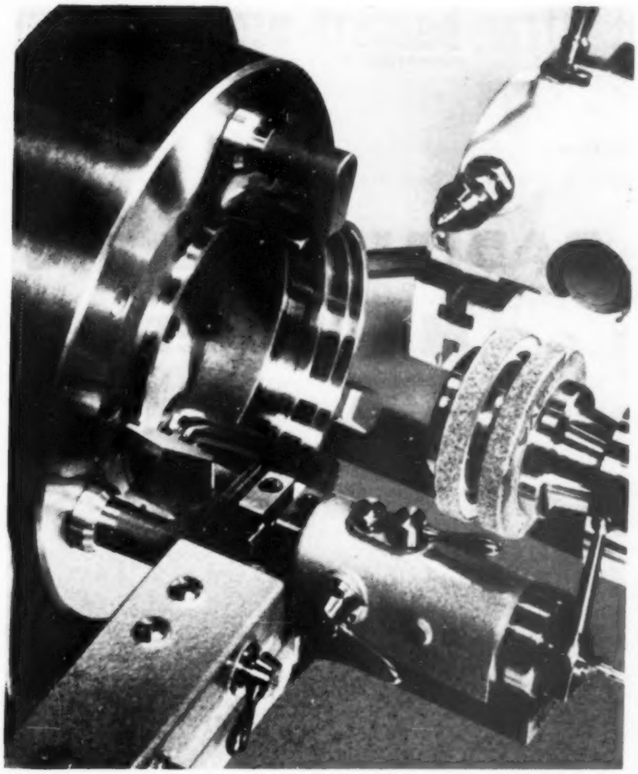

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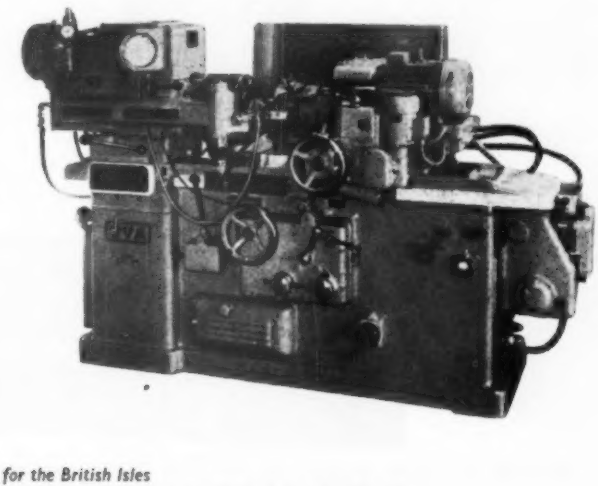
U.V.A. Internal grinding machines are built to the highest standards of precision and are designed for both long-run production and individual development work. The illustration shows a U.H.V. type machine arranged for grinding a bearing sleeve which has an inner flange which requires grinding on both sides. Sizing is controlled by three measuring fingers, one controlling the two diameters and the other two the faces of the flange and thus its thickness. Two grinding wheels are used and can be seen clearly in the close-up view. Write for full details of the U.V.A. range of high-precision grinding machines.



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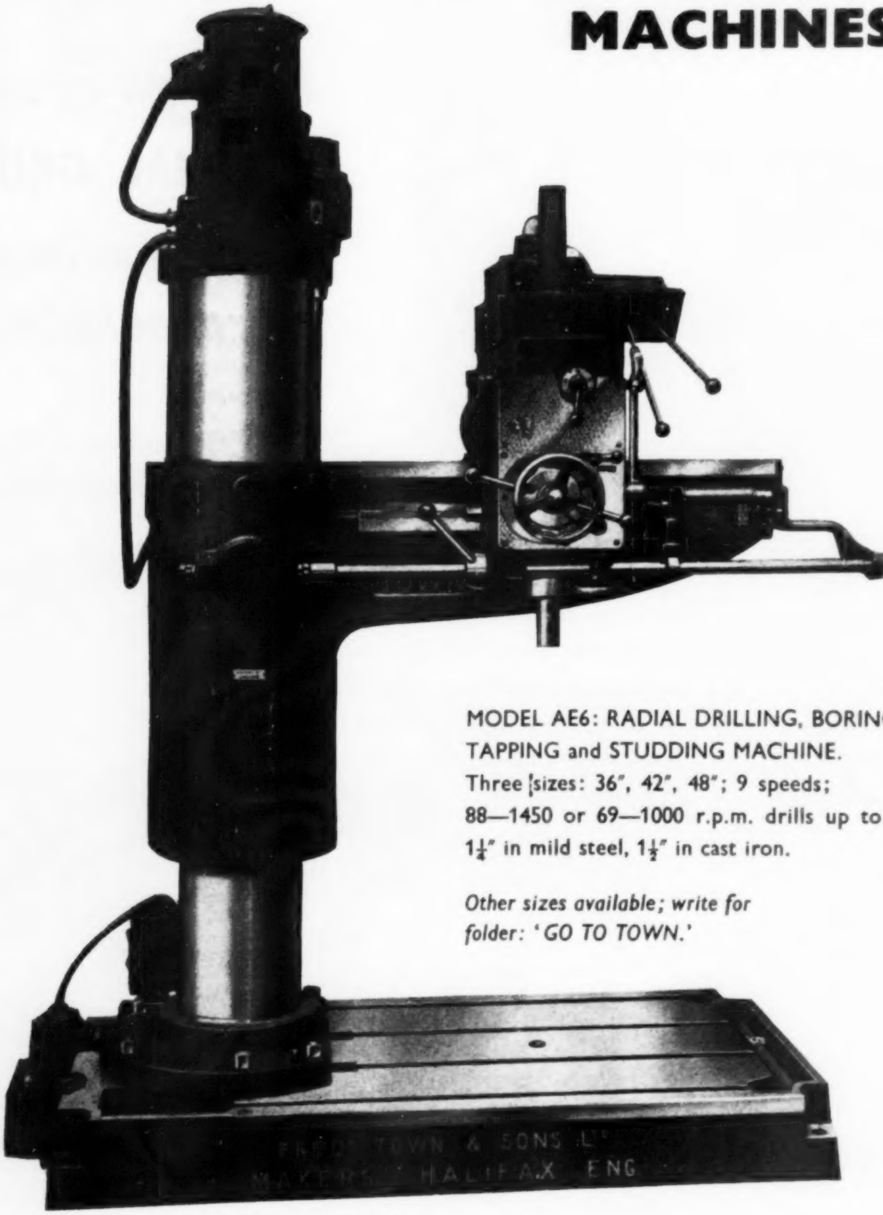

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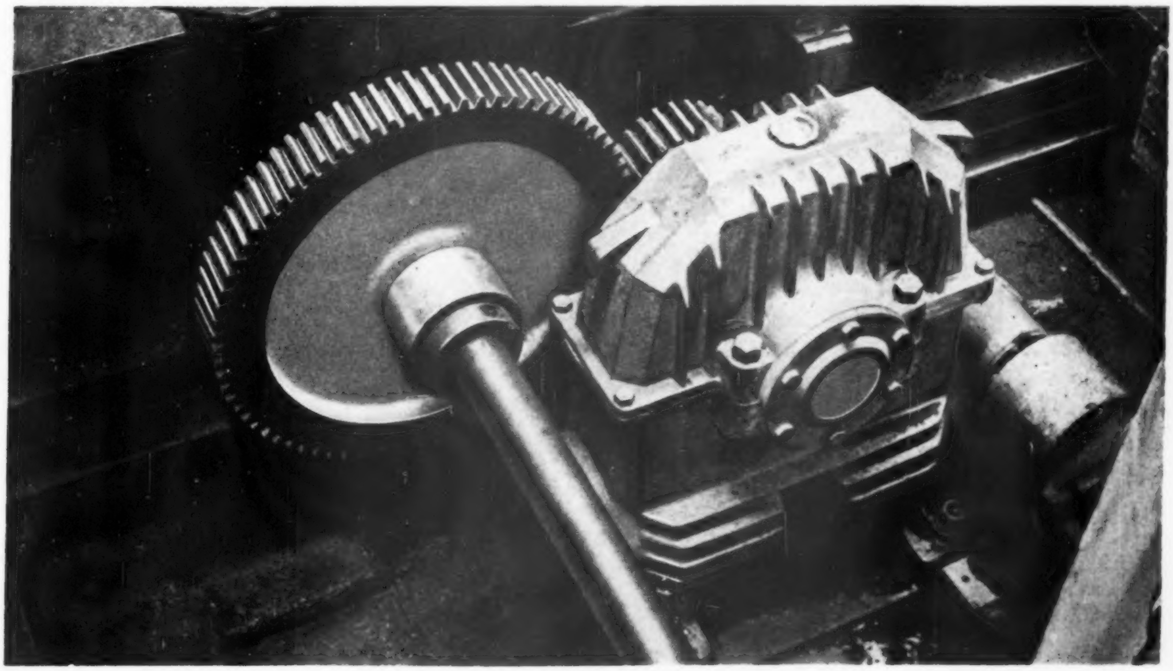

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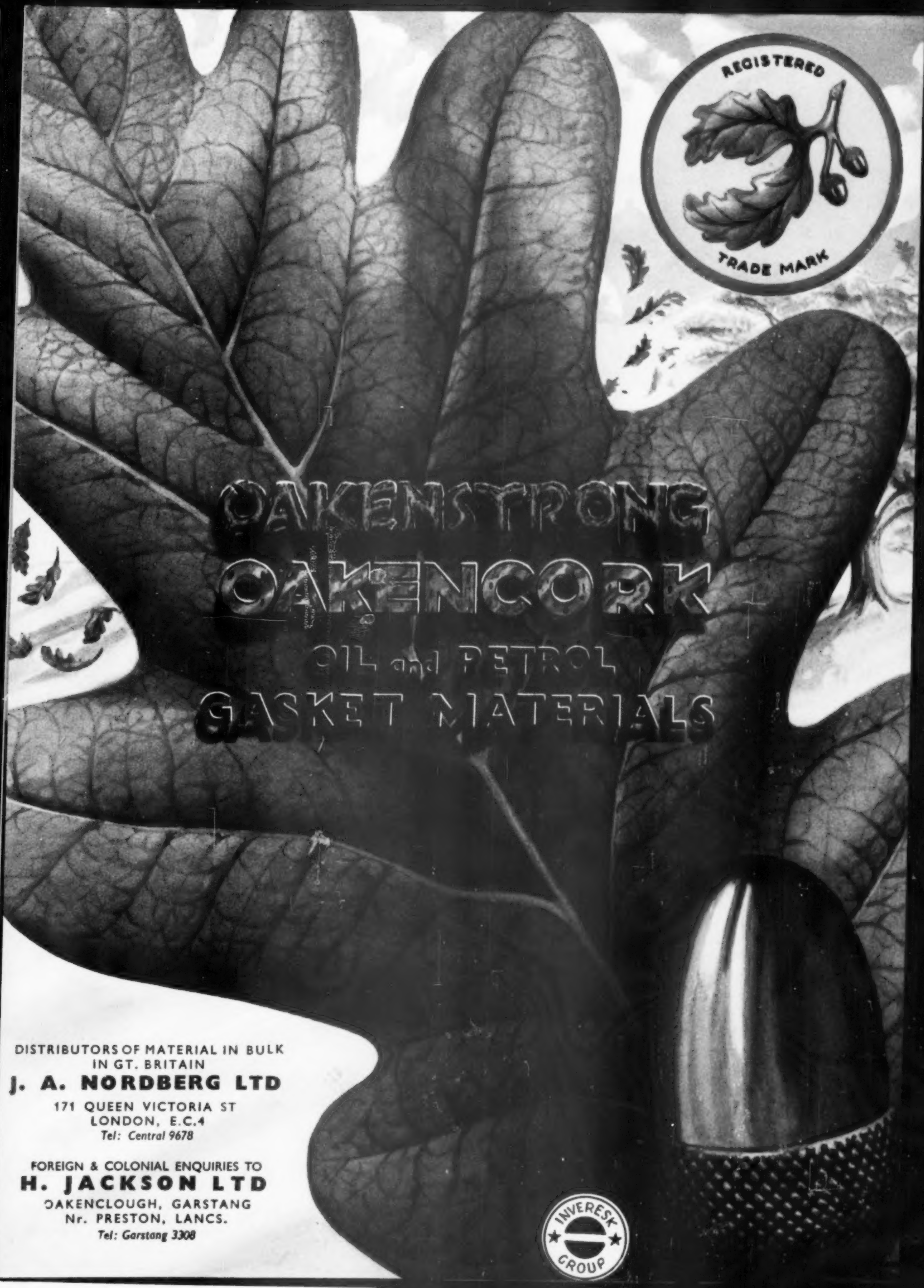
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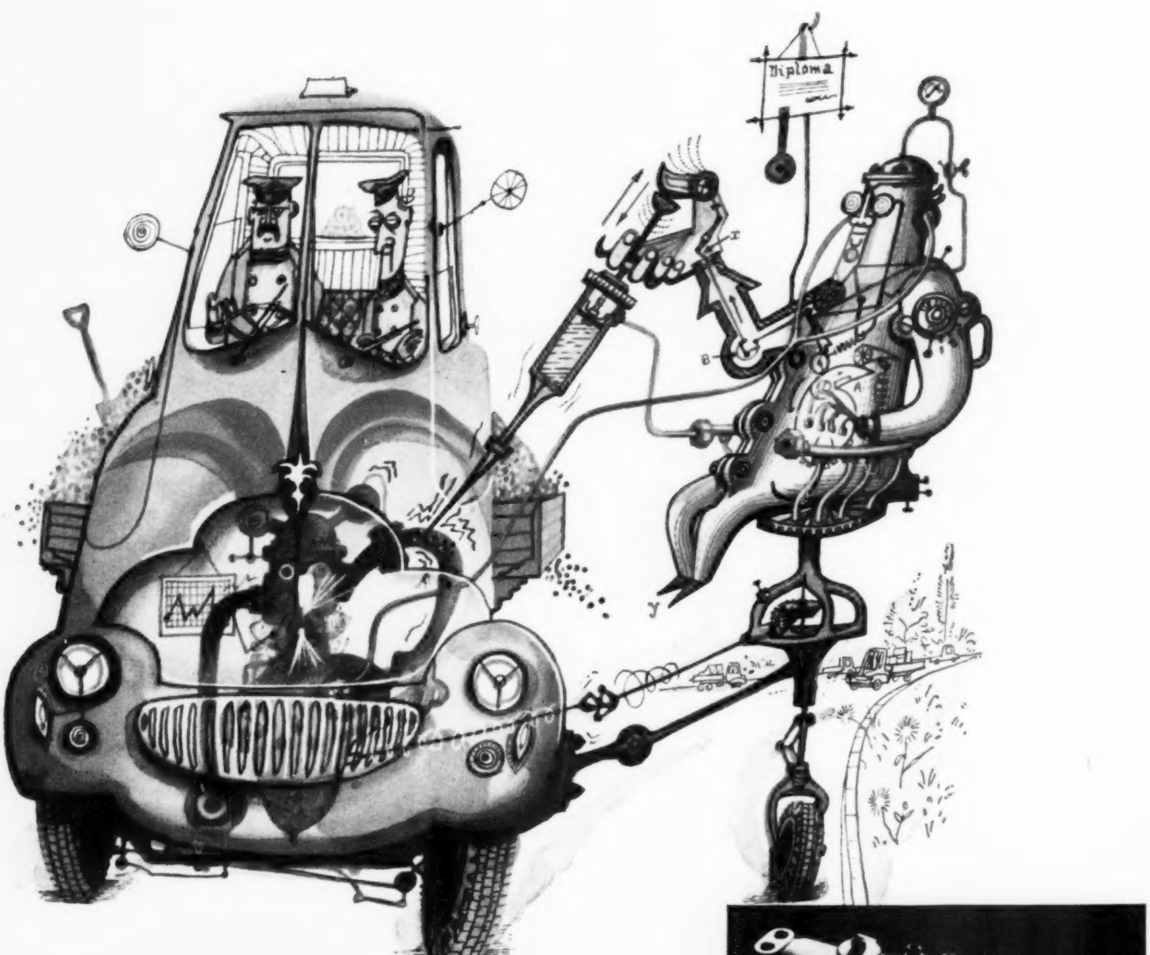

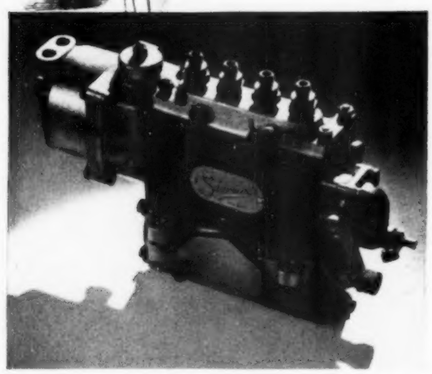

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Mr. Well's time machine (which hasn't been invented yet) was demonstrated—by candlelight—in the cosy Victorian back room from which it took off for centuries from now. That was about the time (1895) F. R. Simms was burning the midnight gas at work on magneto ignition.

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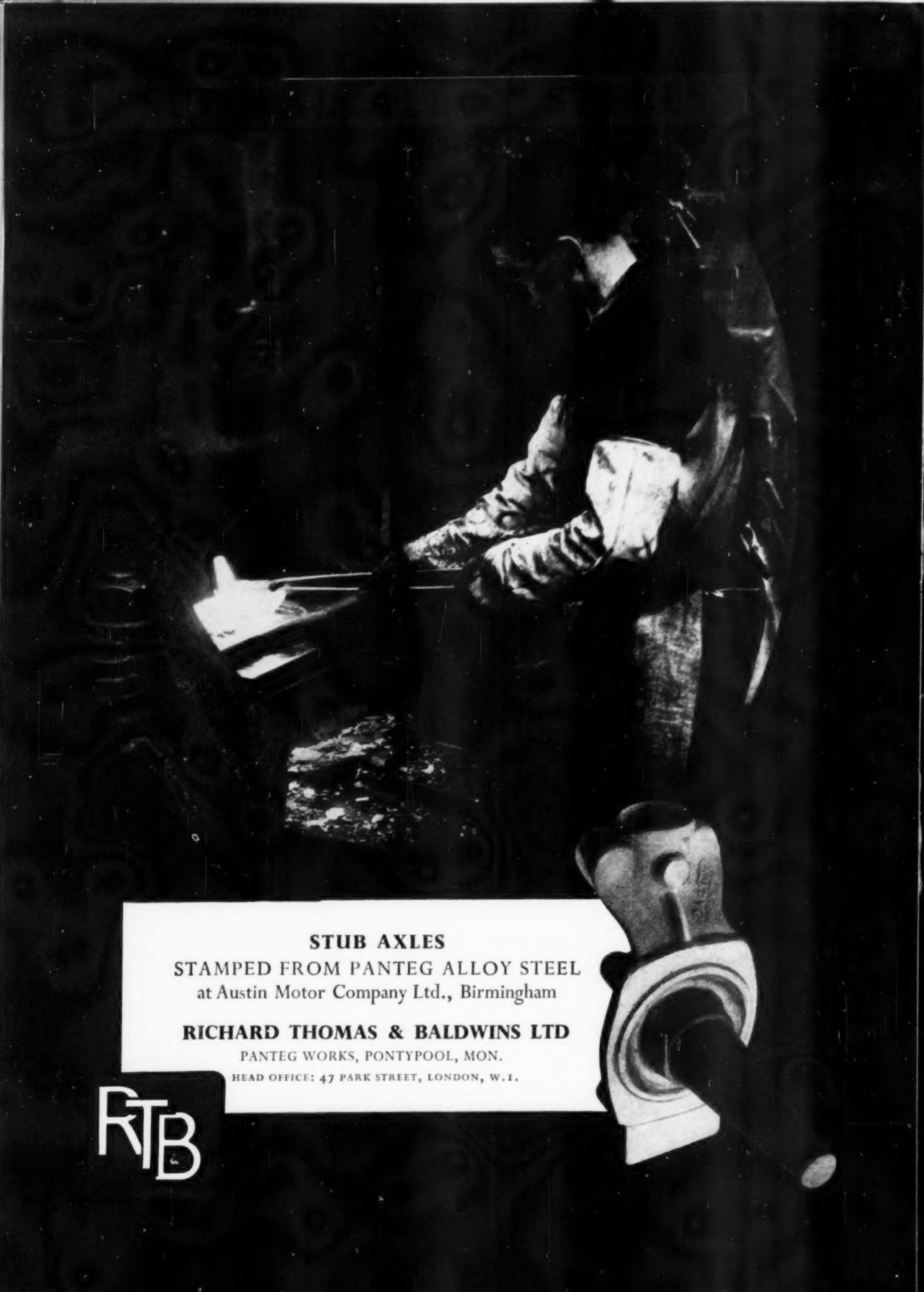
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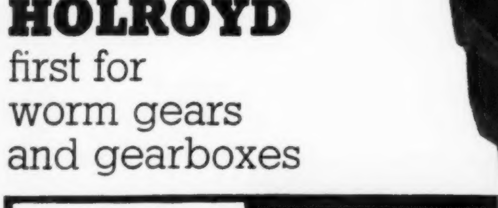

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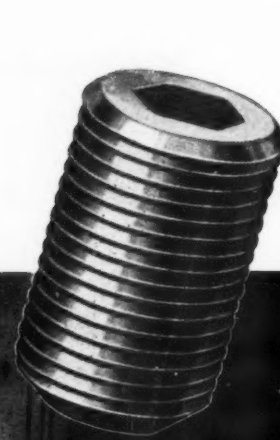

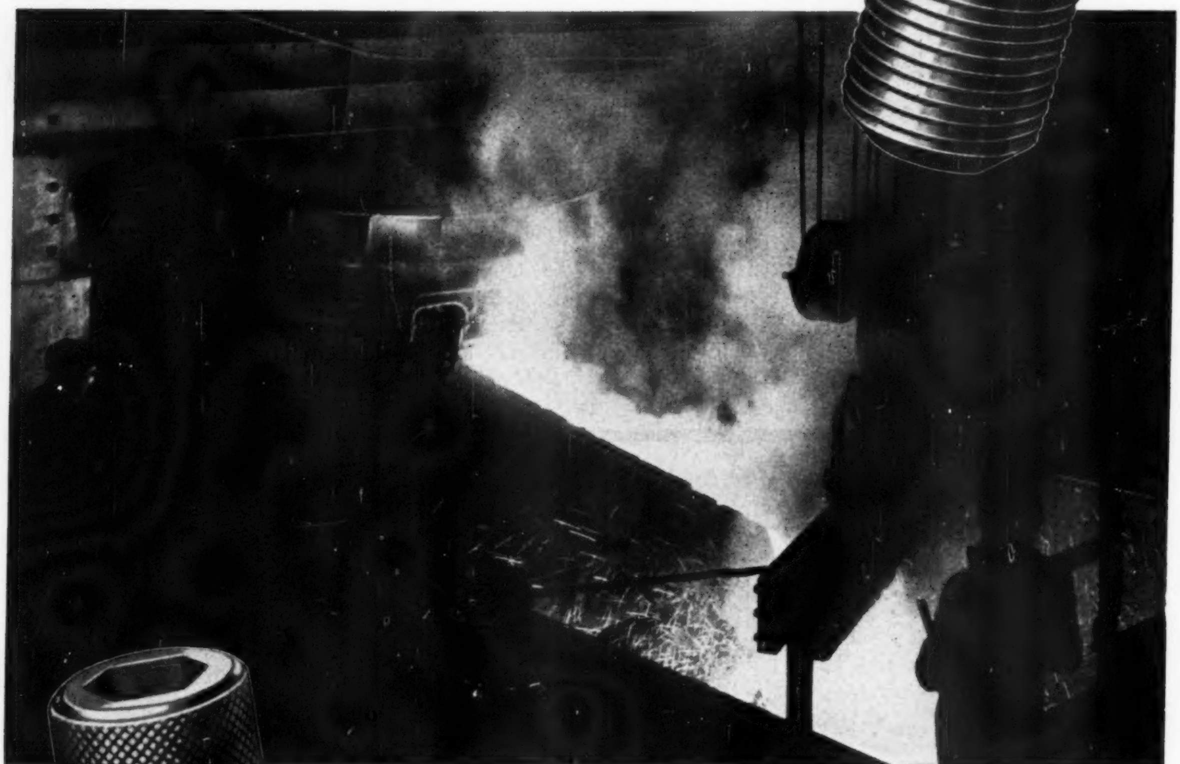

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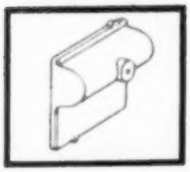

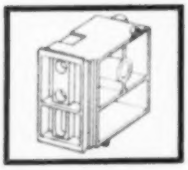

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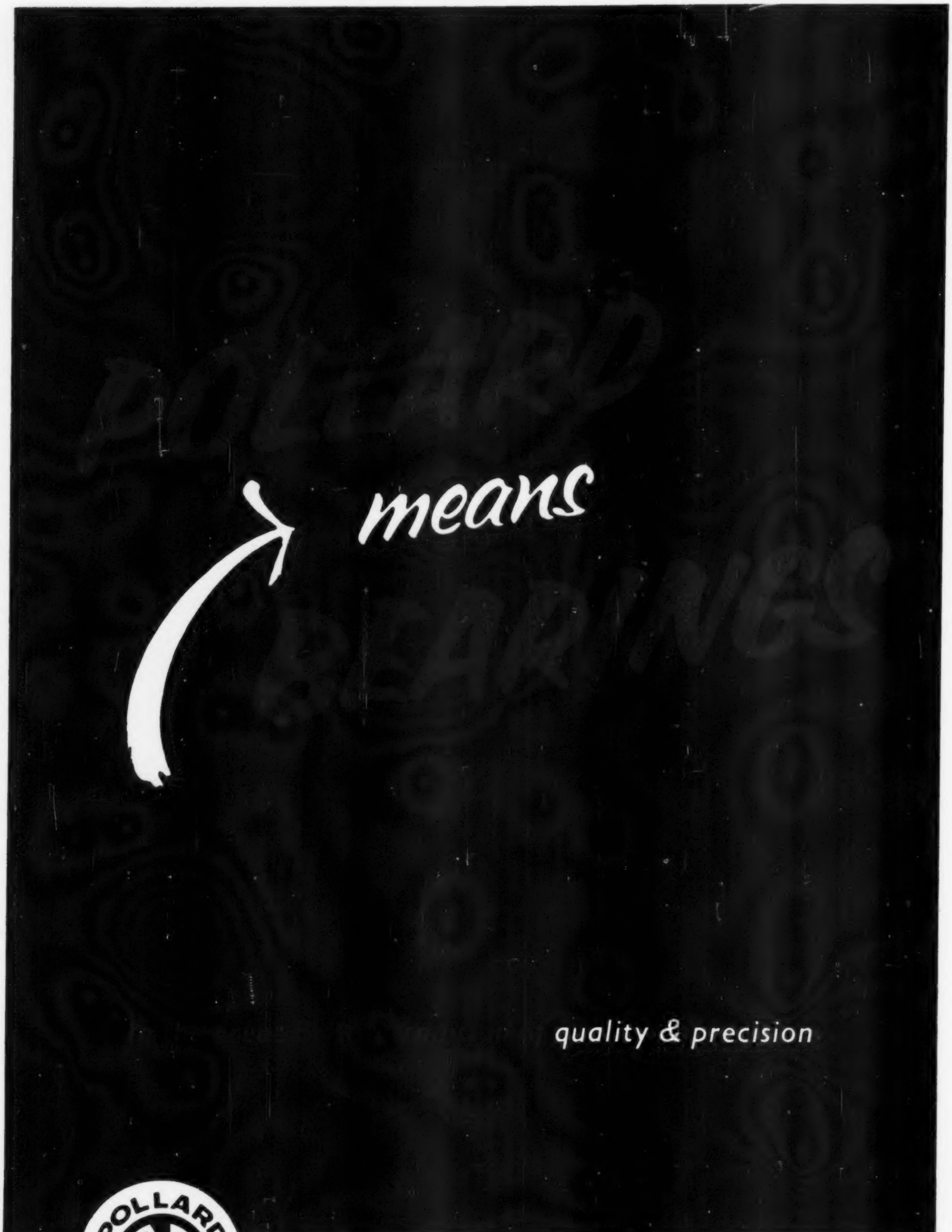

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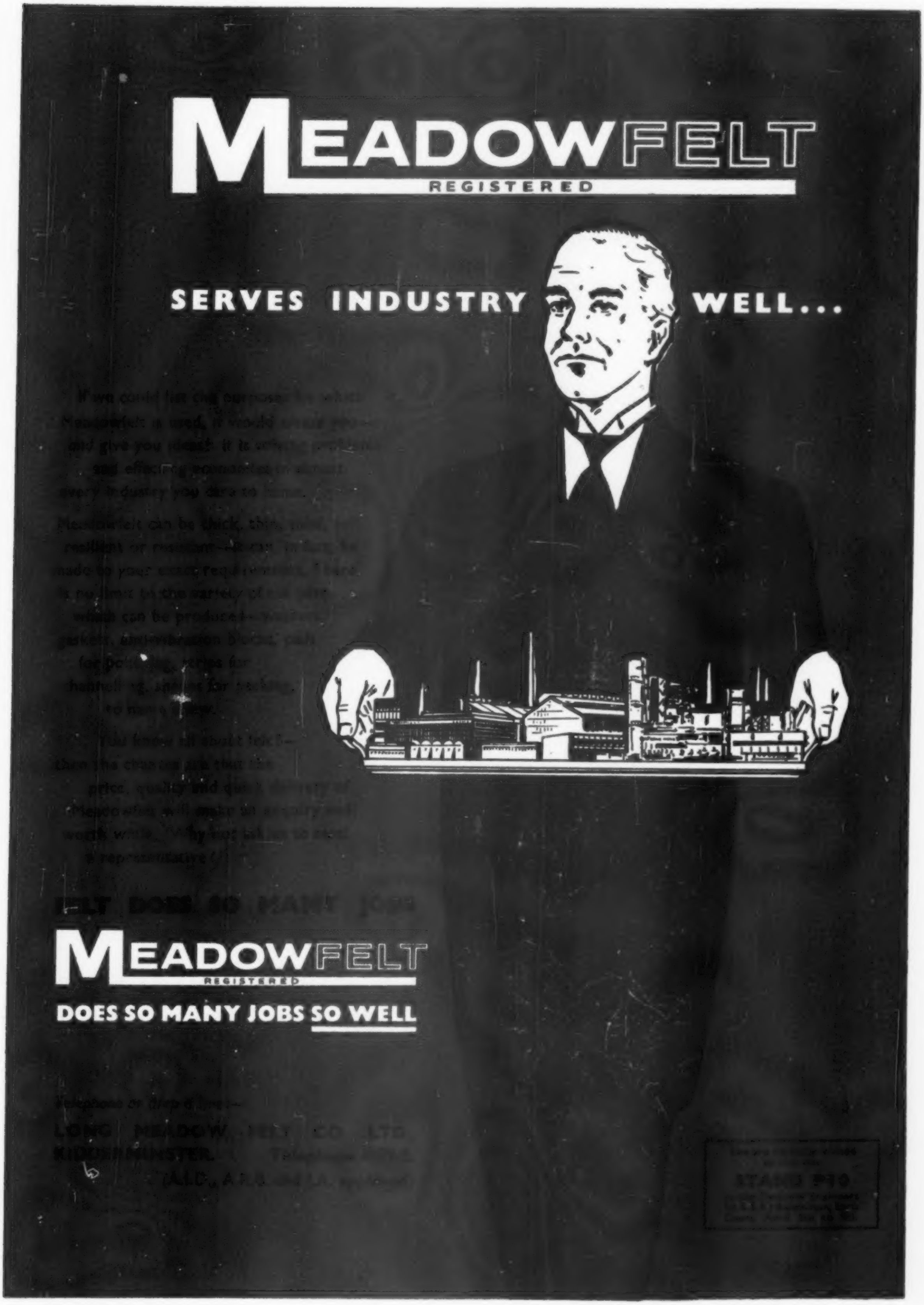
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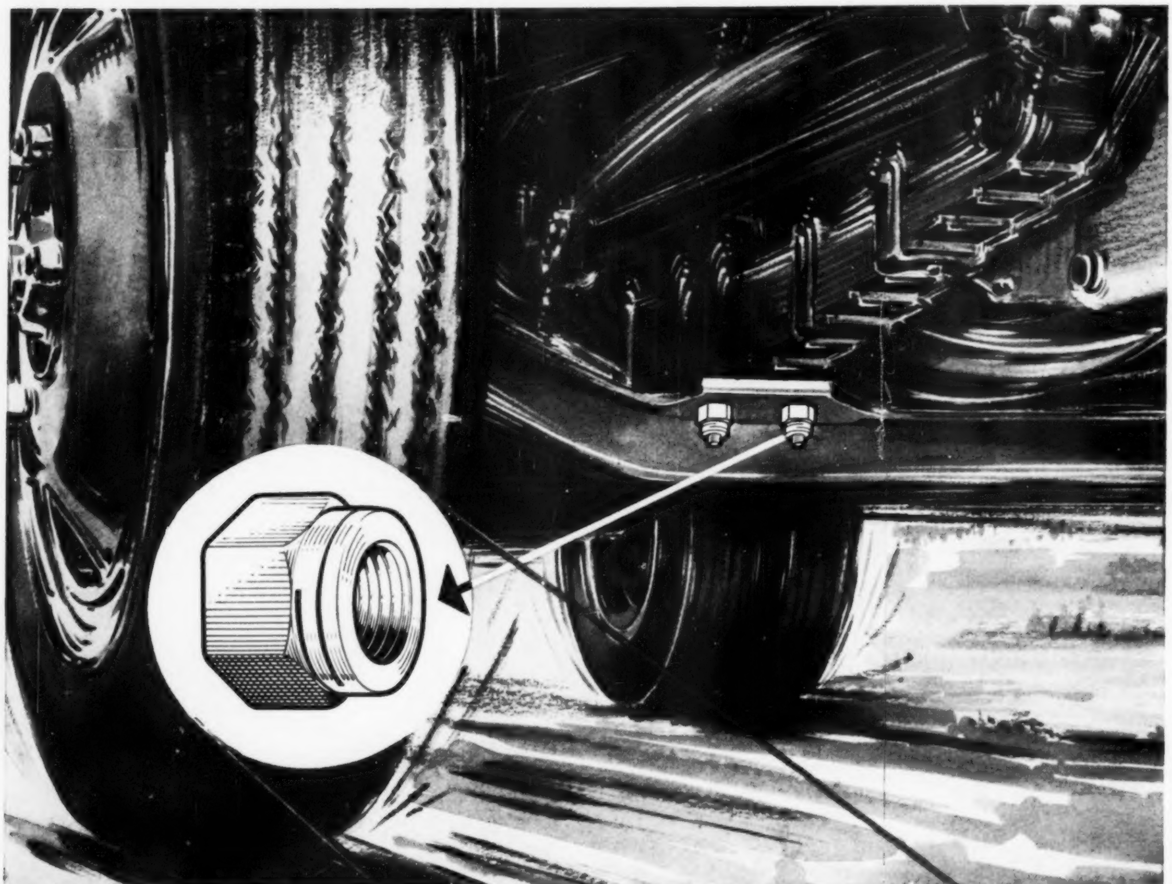

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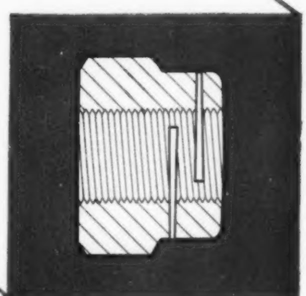

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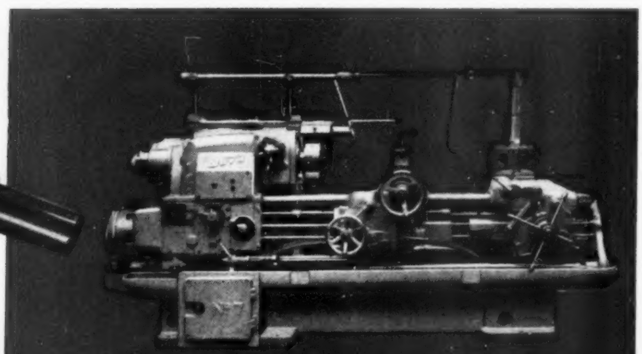

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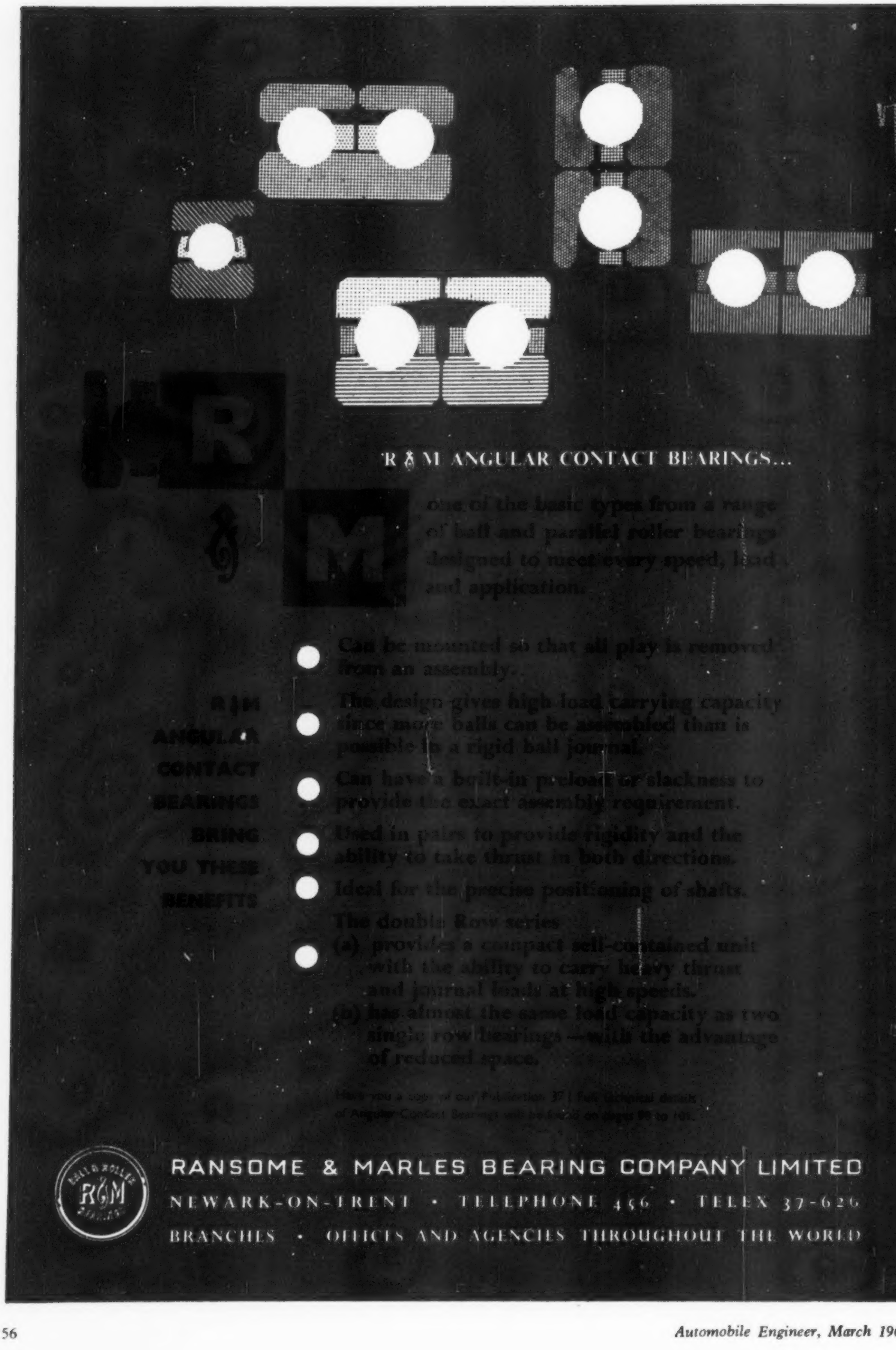
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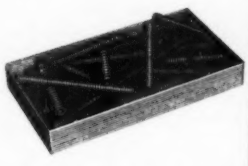

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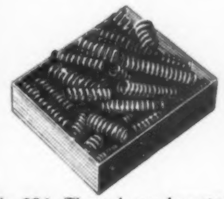

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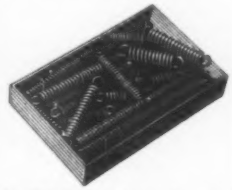

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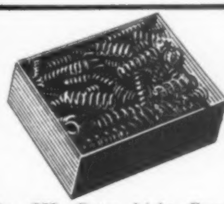

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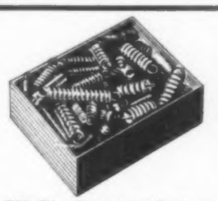

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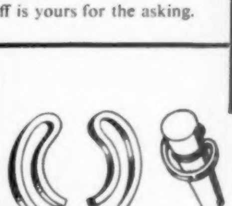

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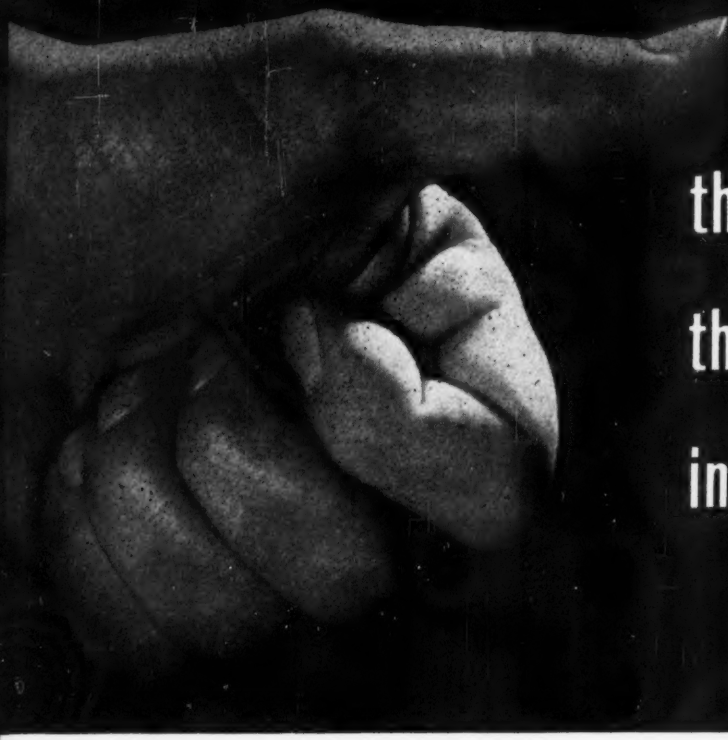

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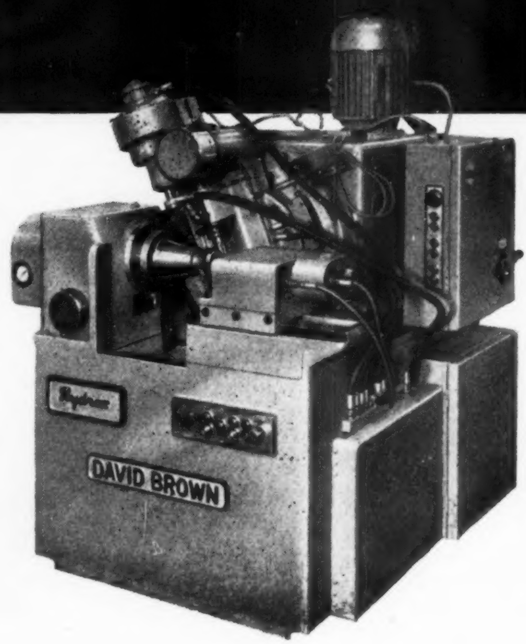

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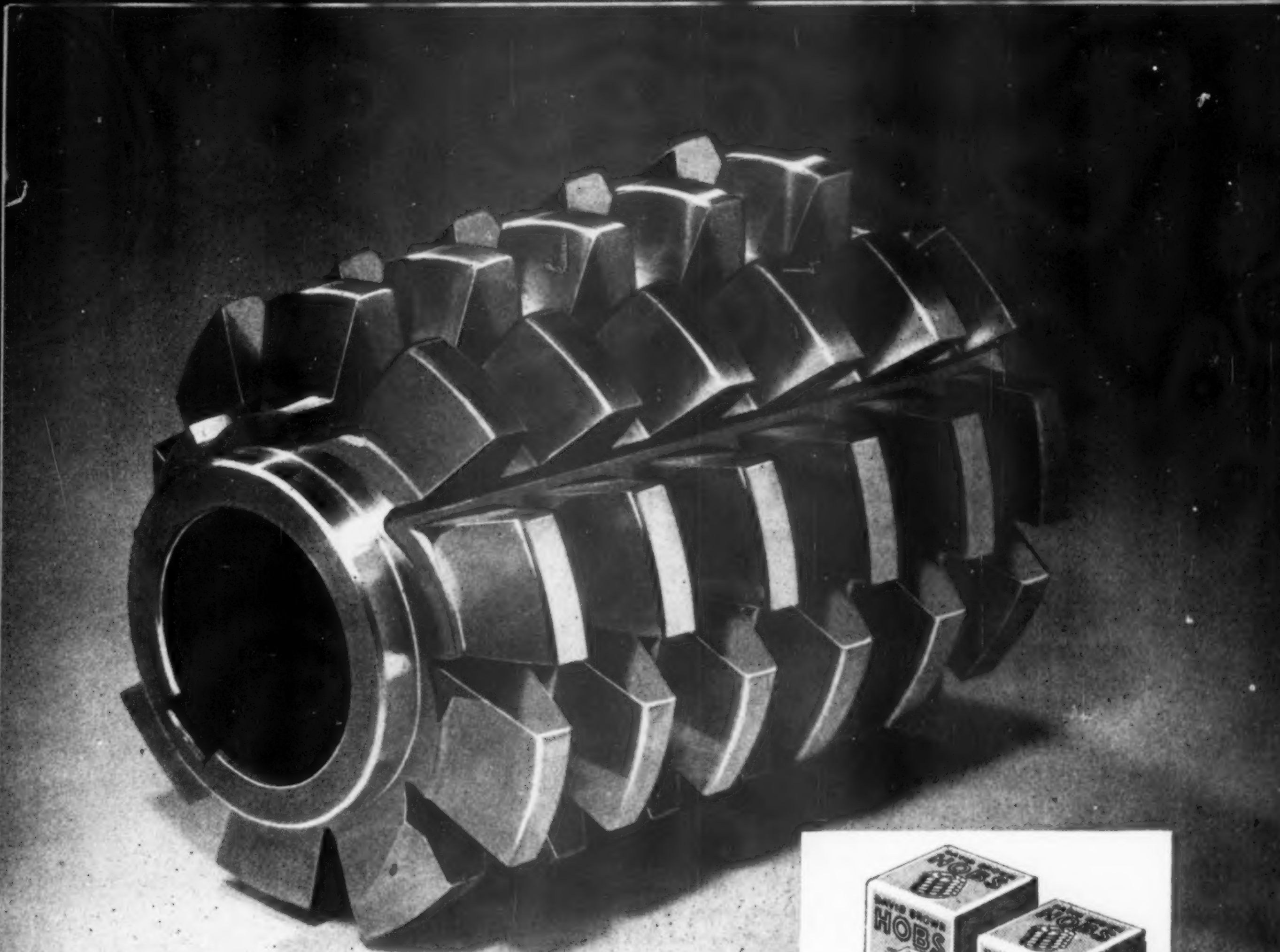

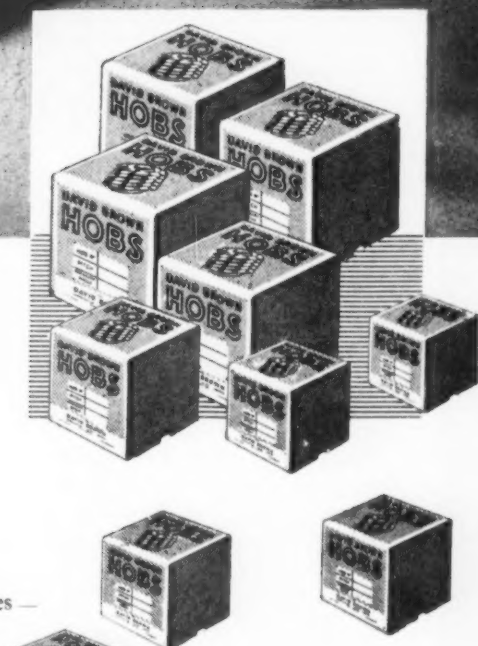

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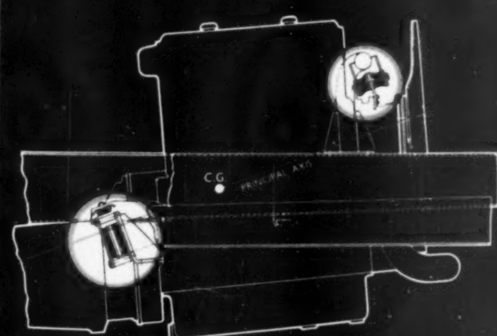
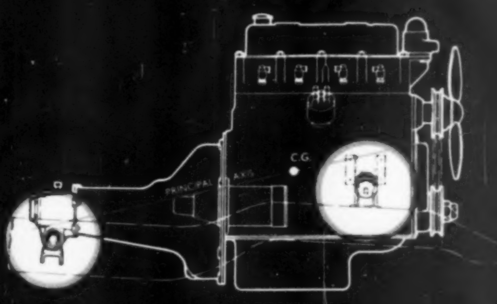


1

If practical considerations could be ignored there would be no problem in providing the ideal suspension for every motor vehicle engine. Mountings would be disposed symmetrically about all three principal axes of inertia and fitted on the longitudinal axis on the lines of "Floating Power" — the suspension technique developed by Metalastik in this country Such an arrangement is not often convenient and the most successful engine suspension is generally a compromise, simulating as closely as possible the characteristics of the ideal but respecting the claims of easy installation and other technical and economic factors so often at variance with theoretical perfection.

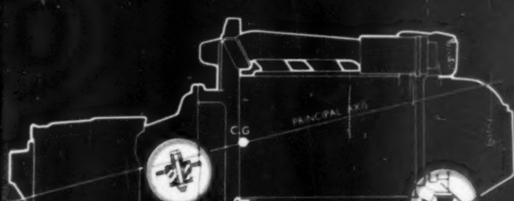
Examples of Metalastik suspension in Figs. 1, 2 and 3 illustrate how a combination of sound theory, appreciation of the practical and choice from an unequalled range of mounting units, bring maximum smoothness to different types of engine.



2

The suspension in Fig. 1 with the high front mounting resembles more closely the original "Floating Power" conception than is now usual. Secondary out-of-balance forces and a flexible chassis necessitate mountings with a large degree of vertical and rotational flexibility, hence the use of shear mountings at all three points. Pre-compression of the rear mountings permits higher stressing without loss of fatigue life.

Fig. 2 shows a typical suspension for a 4-cylinder motor car engine. Interleaved sandwich mountings are below the principal axis but 'focused' in 'V' formation to give the same rotational characteristics as mountings fitted higher but with their compression axes in a vertical plane. The Metaxentric bush at the rear controls fore-and-aft movement and has a higher deflection than a concentric type.



3

For the 3-cylinder opposed piston engine (Fig. 3) in which balancing has virtually eliminated the primary, vertical out-of-balance couple, slotted Metacones and the way in which they are fitted, provide high rotational flexibility about the vertical axis essential for insulation of vibration due to a horizontal out-of-balance couple.

Diagrams reproduced by courtesy of the Institution of Mechanical Engineers from "The Suspension of Internal Combustion Engines in Vehicles", by —
M. Horovitz, B.Sc. (Eng.), A.M.I.Mech.E.

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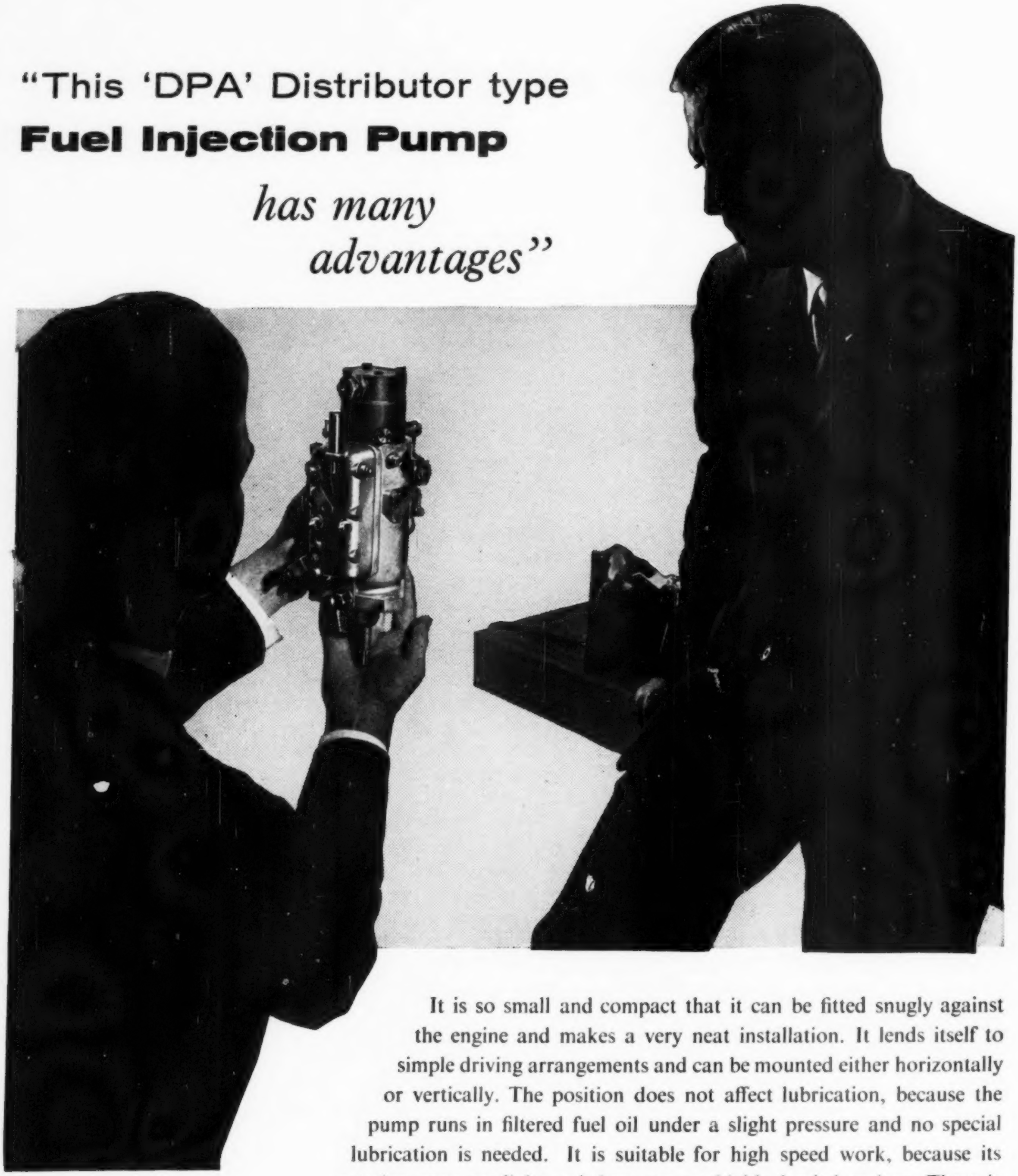

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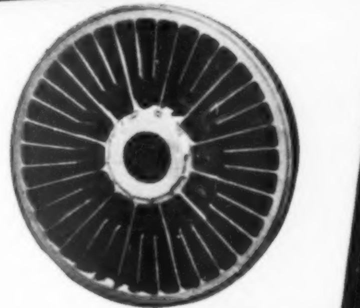

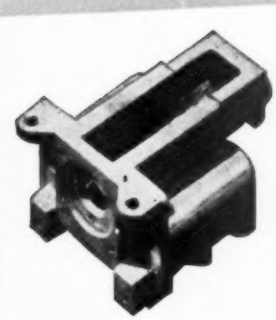

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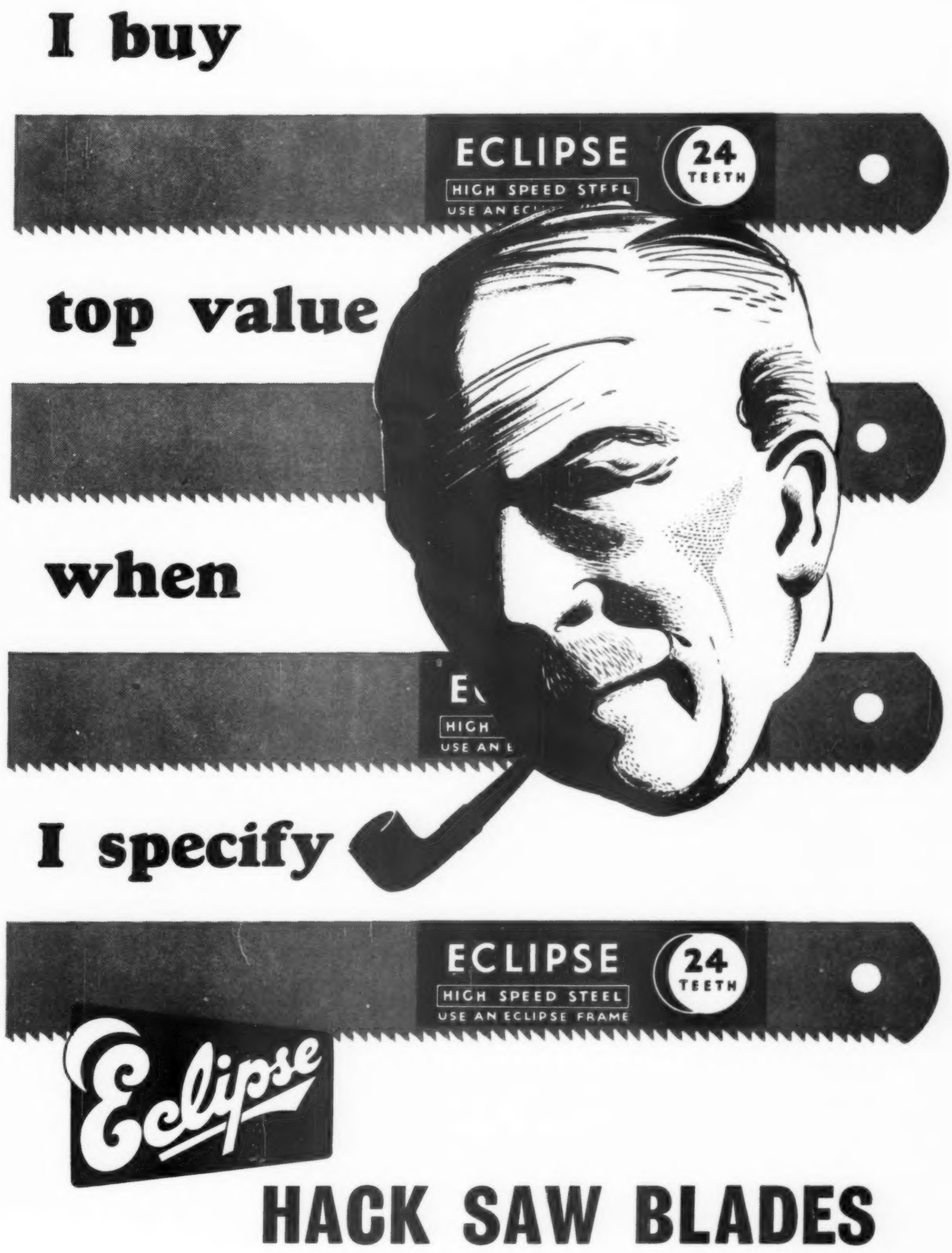

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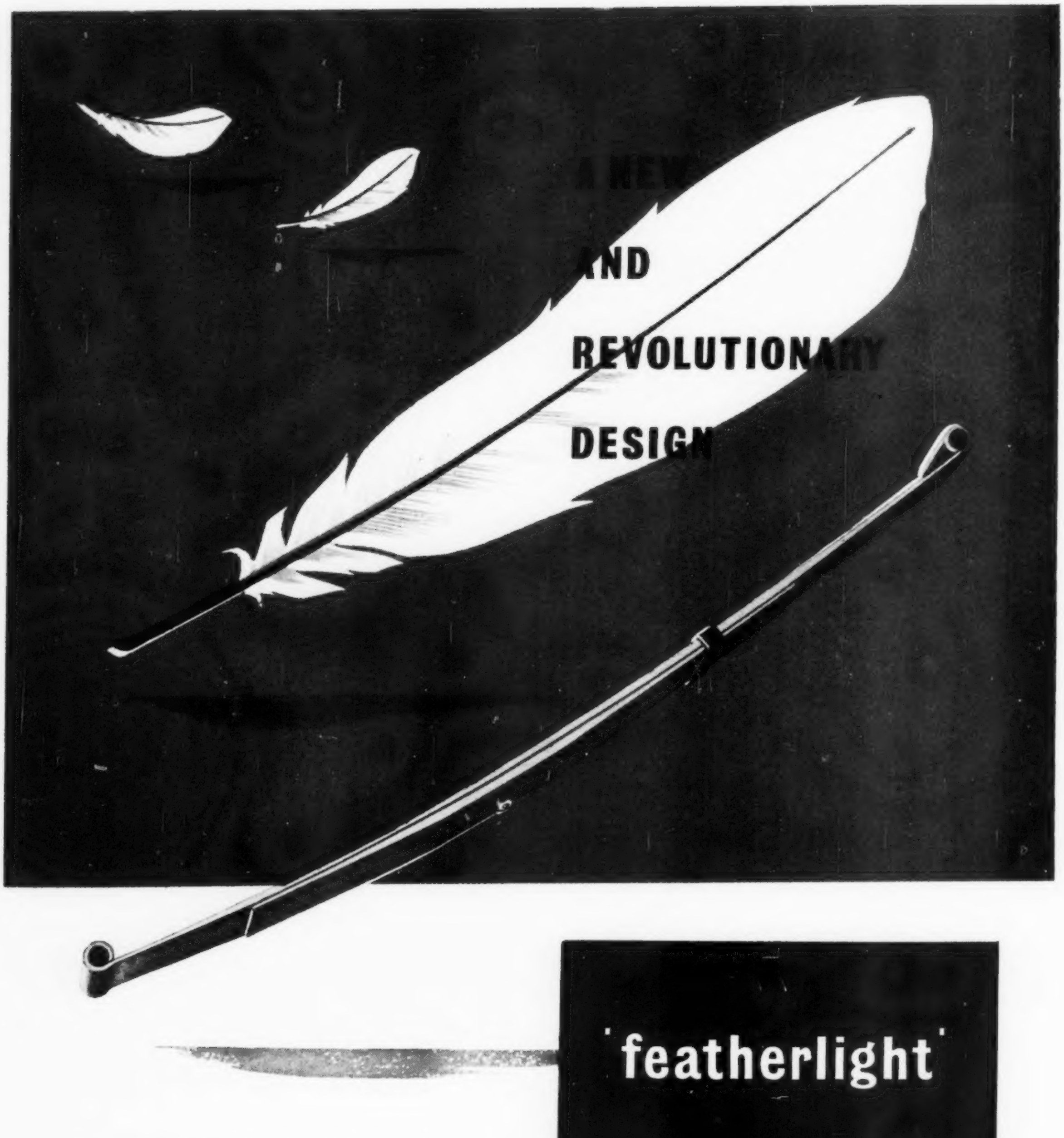

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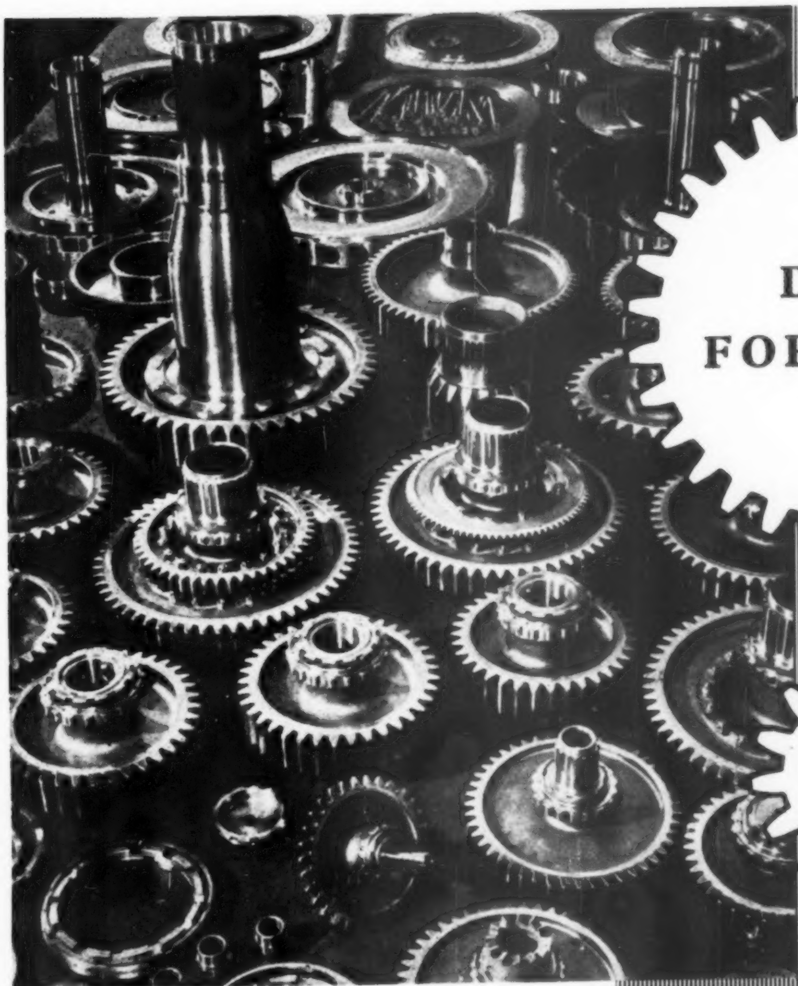

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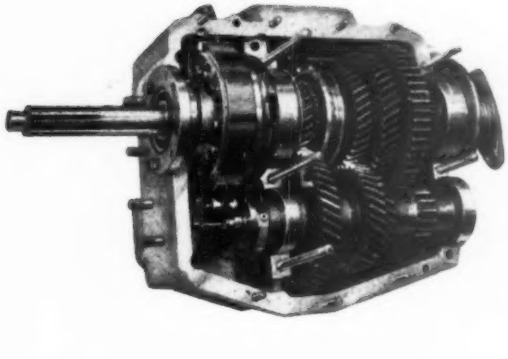

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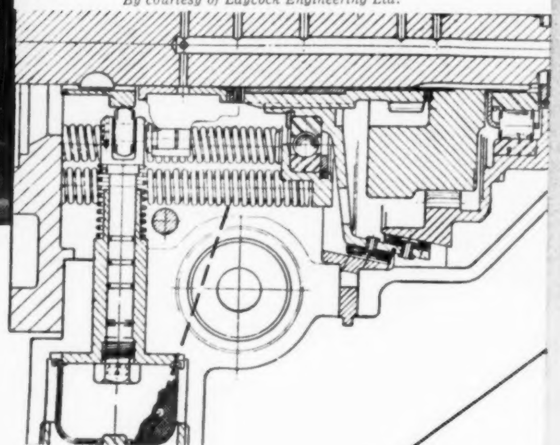

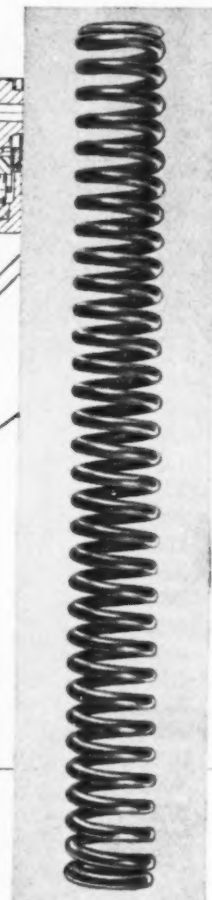

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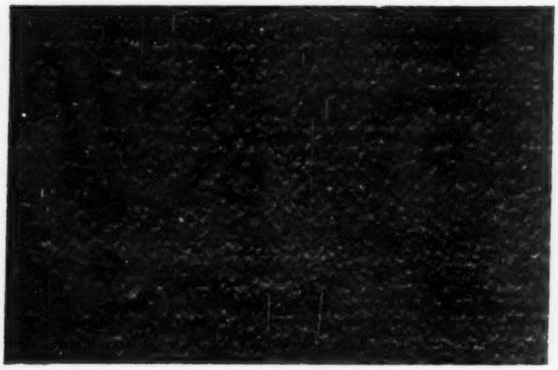

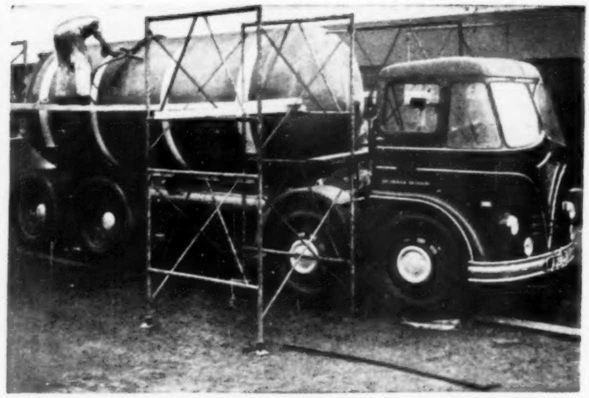

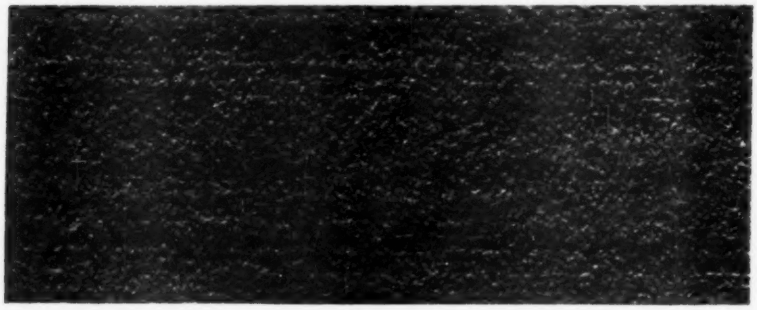

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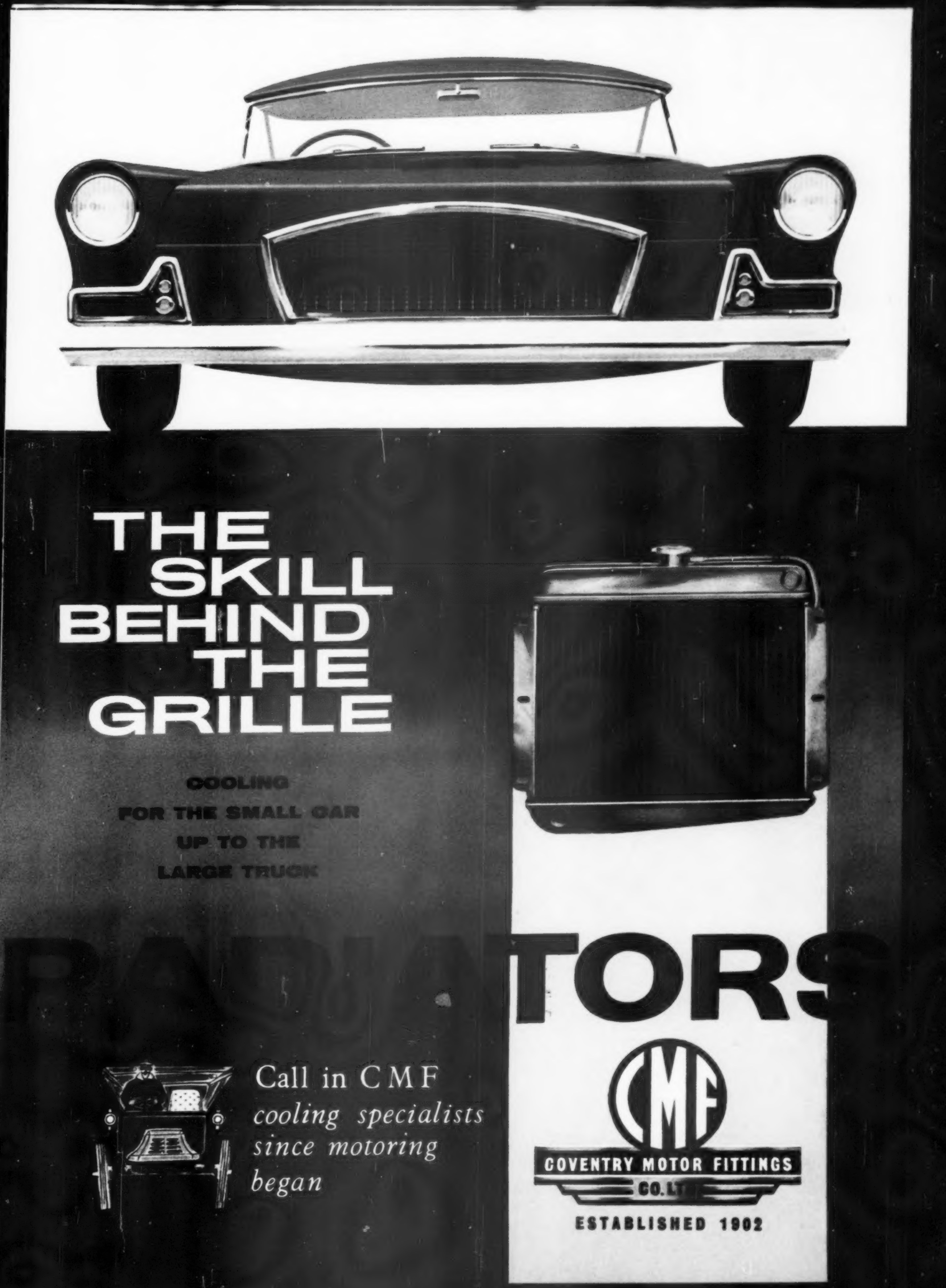
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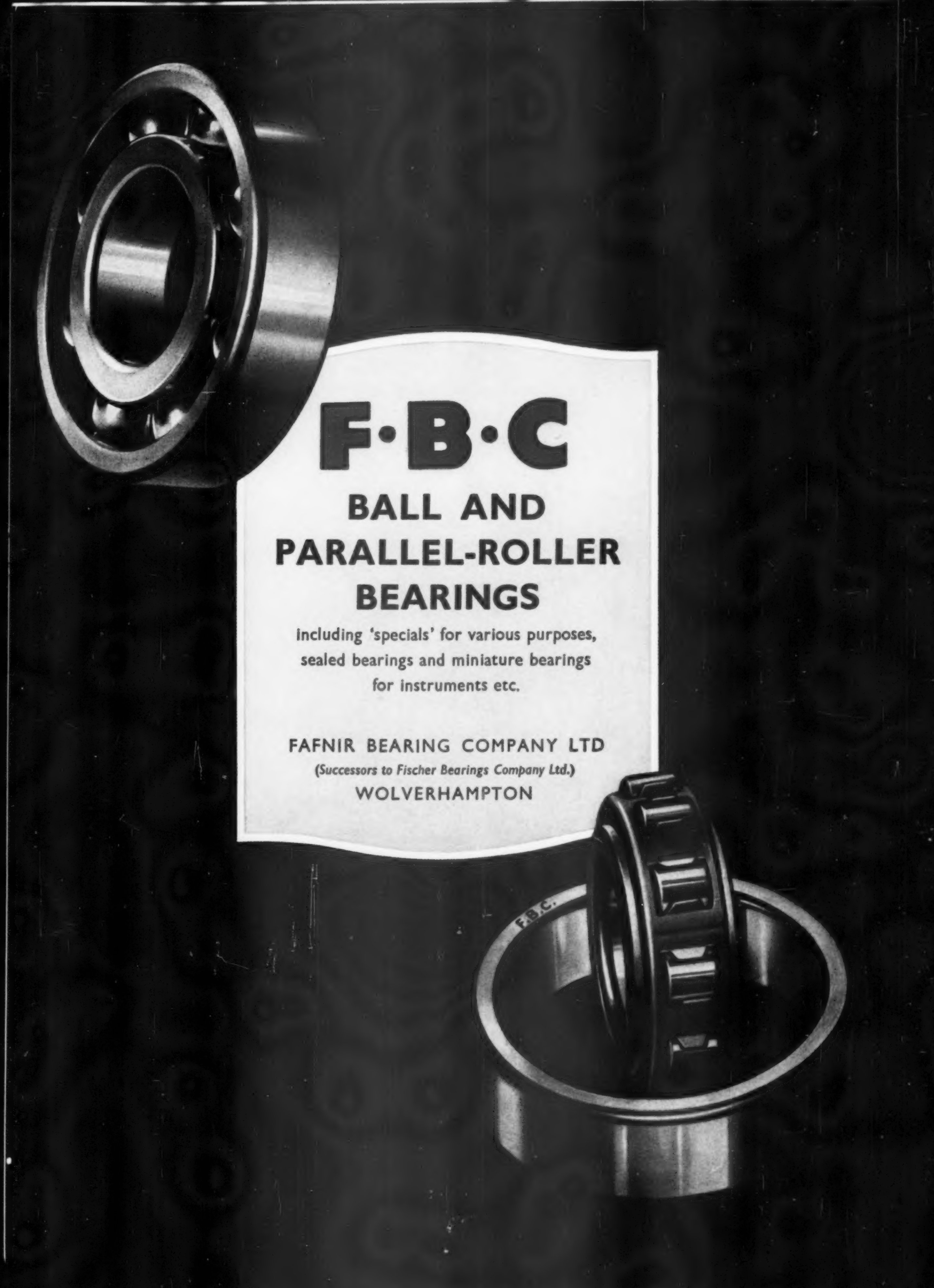
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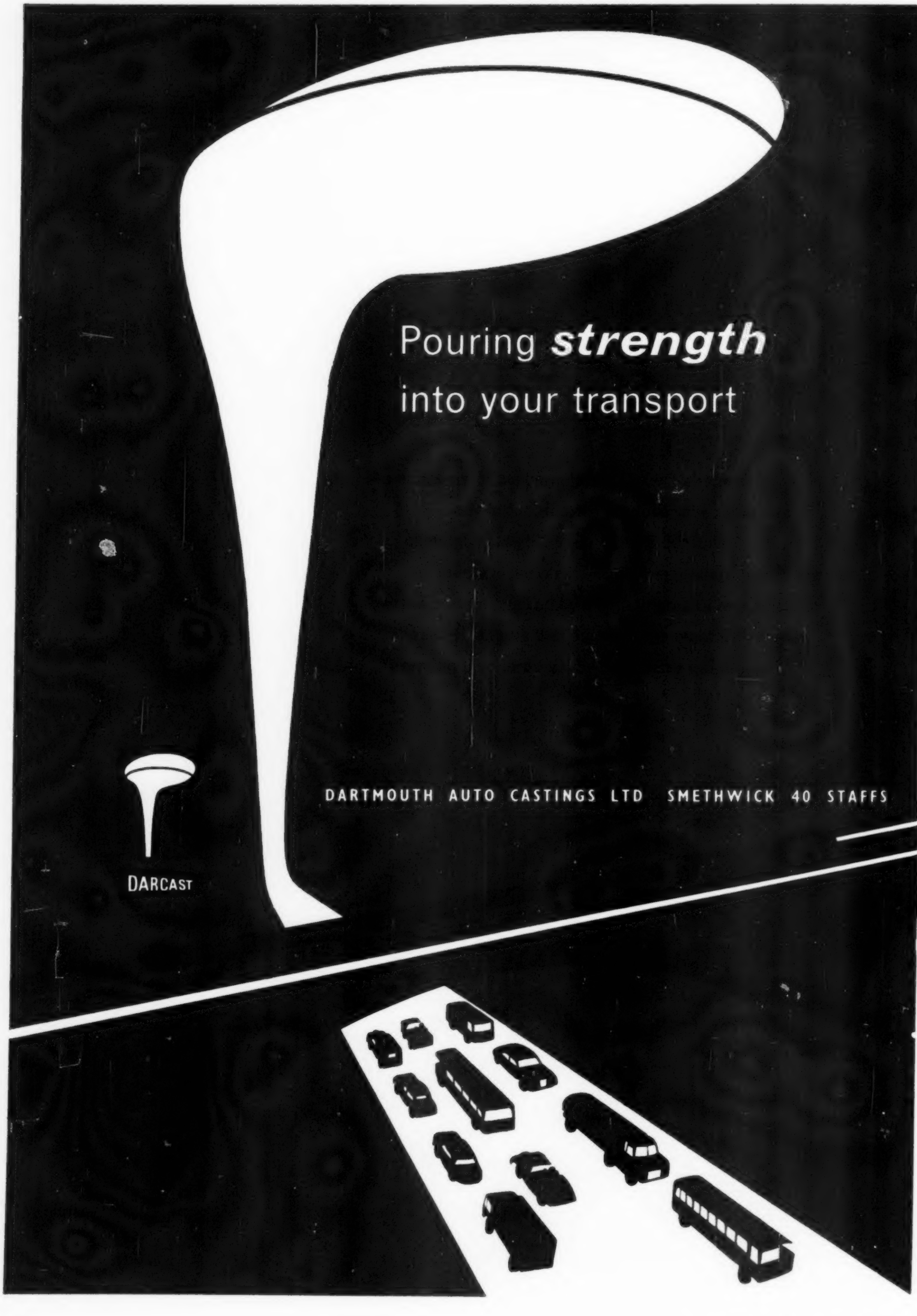
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Telephone · Midland 7191
Manchester · 260 Deansgate, 3
Telephone · Blackfriars 4412 and Deansgate 3595
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Editorial Staff F. C. Sheffield (Associate Editor)
A. Baker, B.Sc., A.M.I.Mech.E.

DESIGN MATERIALS **AUTOMOBILE ENGINEER** PRODUCTION METHODS WORKS EQUIPMENT

New Developments in Arc Welding

WITH the current trend towards automatic assembly, it seems certain that, for many applications, the carbon dioxide shielded arc process will soon supplant other methods of welding. Although this type is scarcely novel, it has not been widely used before because some disappointing results have been obtained. However, as an outcome of investigations undertaken in the U.S.A., the U.S.S.R. and in Great Britain—in the last-mentioned country largely by the British Welding Research Association—the process has now been improved to such an extent that, where it is applicable, much better results can be obtained than are possible with the common arc welding processes, and with greater ease.

Previously, when carbon dioxide shielded arc welding equipment has been used for welding ferrous materials, the welds may have tended to be irregular, with considerable spatter. These adverse effects are experienced because, with the conventional equipment, the metal is projected across the arc in an erratic manner. A modified process has now been developed in which the molten metal is deposited directly from the end of the electrode into the weld pool.

To achieve this, it was necessary to produce equipment operating with a short-circuiting arc at a low voltage, and to design into the electrical circuit sufficient inductance to prevent excessive rise in current when the globule of molten metal on the end of the electrode touches the weld pool. The result is a smooth and rapid transfer at a rate of 100 or more globules a second and a marked reduction in spatter. Most important of all, because of the low current employed, it is now possible to make really good welded joints on sheet steel as thin as 0·048 in.

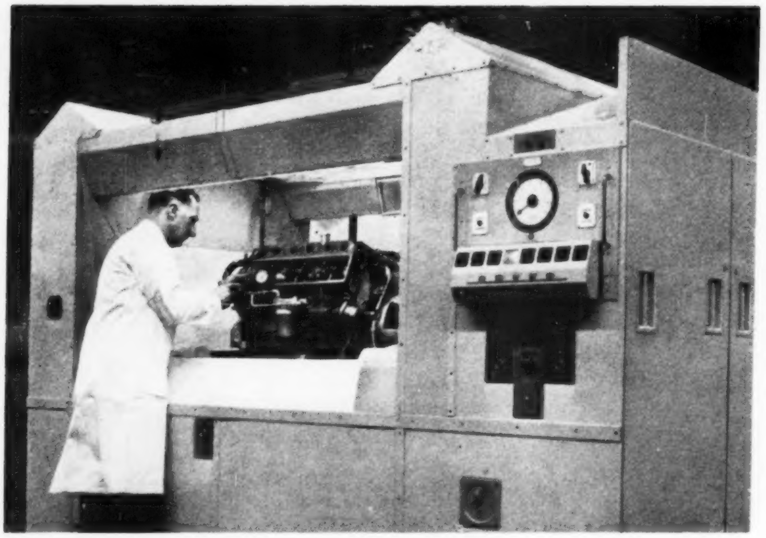
There are many reasons why this process is worthy of serious consideration. Little skill is required of the operator. Welding can be carried out on components in position on the line instead of on a bench or in a separate jig; in fact, it is even possible to weld with the gun pointed upwards. With mechanized welding equipment, a high speed of operation is obtainable: a rate of 50 in/min is practicable with 0·064 in thick material, and this is about three times that of the normal hand welding process. Carbon dioxide gas is relatively cheap, and the results are much better than those obtained by the use of a flux, which is liable to give rise to slag inclusion. The gauge of material that can be welded satisfactorily by this method is thinner than has hitherto been practicable, and the danger of distortion of the assembly is greatly reduced.

A light-weight gun can be employed and it is a relatively simple matter to incorporate in it a timer, for accurately controlled tack-welding. Since precision equipment can be used, the process is particularly suitable for adaptation to automatic welding machines, as has already been done, in the United States of America, for the production of chassis frames of exceptionally complex shape. The fact that the weld is continuous and neat in appearance implies that thin gauge structures fabricated in this way should have good fatigue resistance characteristics.

So far as the cost of materials alone is concerned, there is hardly likely to be much difference between this method and hand welding with stick electrodes. With the new gas shielded process, the additional cost of the gas is offset by virtue of the fact that a continuous wire electrode is employed, so there is practically 100 per cent material utilization, which, of course, is not possible with stick electrodes; also, bare electrode wire can be employed instead of the more expensive flux-coated material. Where significant savings can be made, however, is in respect of time and also because of the facility with which the process can be adapted for automatic or semi-automatic assembly.

There need be little or no delay in the application of this process to current production lines. Conventional guns can be employed, although there is scope for improvement in the design of this equipment. Manganese silicon steel wire with, perhaps, about ½ per cent aluminium included in its specification, is suitable and can be obtained in adequate quantities without any difficulty. The only special requirement is a power supply unit of the appropriate characteristics.

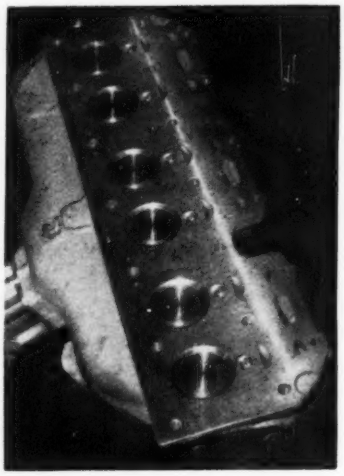
A carbon dioxide shield cannot, of course, be used in the arc welding of aluminium and its alloys, because of the oxidizing nature of the gas at high temperatures. However, it is entirely satisfactory for ferrous metals. This method of welding is particularly attractive for use with alloy steels, not only because there is no need to use a flux but also because any hydrogen that may be generated is immediately oxidized by the dissociation products of the carbon dioxide. Even stainless steel can be welded by this method, although there is a tendency for carbon pick-up to occur. One thing perhaps remains: there may be scope for future development in connection with the employment of mixtures of gases for the shield, each constituent having a different function to perform.



In case manufacturing tolerances should have combined unfavourably in terms of balance, each partially erected engine is motored on this machine, which reveals any vibration. Should excessive roughness be observed, the engine would be rejected; the permitted limits are given as ±2 oz-in

Part II: The Engine, Automatic and Manual Transmission Systems, Propeller Shaft and Spiral-Bevel Rear Axle

ROVER 3 LITRE



The inlet manifold is cast integrally with the aluminium alloy cylinder head, and is water heated. On the flat under-surface of the head can be seen the recesses giving clearance above the exhaust valve heads

THE 2,995 cm^3 six-cylinder engine of the Rover 3 Litre car is largely a development of the 2,638 cm^3 unit fitted to the 90 and 105 models, now out of production. However, both it and the short-stroke version fitted to the new 100 car differ from the earlier engine, in that the crankshaft is carried in seven main bearings instead of four. No significant change, apart from an alteration in the design of the cam followers, has been made to the well-tried Rover valve gear and combustion chamber layout, which was introduced in 1948. This unusual arrangement was, in fact, described in the September issue of *Automobile Engineer*, of that year, in a detailed analysis of the Rover 60 and 75 cars. The inlet valves are carried in the cylinder head, which has an oblique joint face to the block, and the side-mounted exhaust valves are inclined: they are situated in side-pockets formed at the tops of the cylinders.

Since the combustion chambers are bounded by the surfaces of these pockets, the under-face of the head and the pent-roof piston crowns, they can readily be fully machined to ensure equality of clearance volumes. Also, the chamber form is compact, with short flame travel and good turbulence characteristics. The design therefore provides a low enough octane requirement to permit a compression ratio of 8·75 : 1 on the 3 Litre unit. Also, since relatively weak mixtures are burnt satisfactorily, the specific fuel consumption is good. Nevertheless, the layout is rather more complex than others, and would not offer any substantial advantage in respect of valve size with lower stroke : bore ratios than those employed by the Rover Co.

To obtain the desired increase in capacity over that of the old 2·6-litre engine, the bore has been enlarged from 73·025 mm to 77·8 mm. Since the stroke of 105 mm is unaltered, the stroke : bore ratio is 1·35 : 1, a relatively high figure by current standards. It is interesting to recall that this stroke was adopted for the first post-war six-cylinder and four-cylinder engines embodying the present valve and combustion chamber layout. These units had bores of 65·2 mm and 69·5 mm respectively, giving the very high stroke : bore ratios of 1·61 : 1 and 1·51 : 1. The 77·8 × 105 mm cylinder dimensions first appeared in the 2-litre four-cylinder engine of 1954, fitted to the model 60 car.

Curves showing the full-throttle power, torque, b.m.e.p. and specific fuel consumption are reproduced in an accompanying illustration. From them it can be seen that the maximum gross power output is 115 b.h.p., at approximately 4,500 r.p.m. At 38·4 b.h.p/litre, the corresponding specific output is satisfactory for a single-carburettor unit. The torque curve is remarkable not so much for its maximum value of 164 lb-ft, but for the fact that this value occurs at so low a speed as 1,500 r.p.m. The corresponding b.m.e.p. is 136 lb/in^2. At 4,000 r.p.m., the highest speed likely to be used for continuous cruising, the torque is still well over 140 lb-ft. The engine should thus have unusually good pulling power at low r.p.m., with the ability to maintain a high cruising speed up gradients and against a strong wind. It is noteworthy, too, that the minimum value of the specific

fuel consumption is 0·493 pt/b.h.p.-hr, and is below 0·50 pt/b.h.p.-hr between about 1,700 and 2,750 r.p.m., a widely used speed range; nowhere does the consumption rise above 0·58 pt/b.h.p.-hr.

At maximum b.h.p., the mean piston speed is 3,100 ft/min. The ratio of maximum torque : torque at maximum b.h.p. is 1·24 : 1, and that of speed at maximum torque : speed at maximum b.h.p. is, of course, very low at 0·333 : 1. In terms of piston area, the power output is 2·6 b.h.p/in^2, and the engine and vehicle power : weight ratios are 0·208 b.h.p/lb engine dry weight and 75 b.h.p/ton vehicle kerb weight, based on the manual transmission model with overdrive.

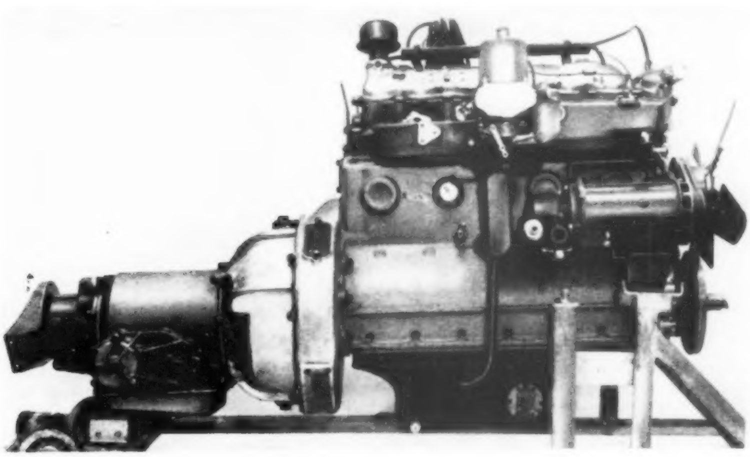
Construction of the engine

The crankcase and cylinder block are a single iron casting, having the sump joint face well below the level of the crankshaft axis, and the head joint face inclined downward to the right at 22 deg to the horizontal. On the left side of the block is a chamber housing the high-mounted camshaft, the cam followers, the exhaust valve stems and the lower ends of the inlet valve push rods. The cylinders are equally spaced along the block and, though the water spaces between them are relatively narrow, they extend down to about the level of the gudgeon pins when at bottom dead centre. At the top of each cylinder, on the left side, is the machined, part-spherical pocket that forms part of the combustion chamber and contains the head of the exhaust valve.

A nickel-chromium forged crankshaft is employed. It has integral balance weights immediately behind number 1 crankpin, ahead of number 6 crankpin, and adjacent to each end of the central main bearing. All the main bearings have the same nominal length, namely 1 11/16 in. Also, the diameters of the main and big-end bearing journals, 2¼ in and 1⅞ in respectively, are such as to provide a small overlap for shaft stiffness. The seating faces between the connecting rods and their caps are at 90 deg to the major axes of the rods, which can be withdrawn and replaced through the cylinders. Thin-wall, steel-backed shells are employed for the main and big-end bearings; they are lined with copper-lead, whereas the small-end bushes are of lead-bronze. At the forward end of the crankshaft is a torsional vibration damper, of unbonded, rubber sandwich type. The body of this damper is grooved to form the pulley for the vee-belt driving the generator and fan.

Connecting rods of either En.12, 1 per cent nickel steel, or En.15, carbon-manganese steel, are used. Since the length of the rods between centres is nominally 7⅞ in, the ratio of that length to the stroke is 1·905 : 1. The slotted-skirt pistons carry two compression rings and an oil control ring. All three rings are above the gudgeon pin, which is appreciably more than half-way down the piston. Because of the proximity of the exhaust valves to the top of the cylinder bores, the risk of excessive local heating of the upper compression rings is avoided by an unusually long top land. The highest point of the piston crown is slightly to the left of the longitudinal diameter. To the right of the apex, the pent roof is flat and inclined at the same angle as is the head-block joint face, whereas to the left it has a concave face.

The camshaft is driven by a duplex roller chain of ⅜ in pitch, and the unloaded run of the chain is automatically tensioned by a Renold SCD hydraulic tensioner. This has



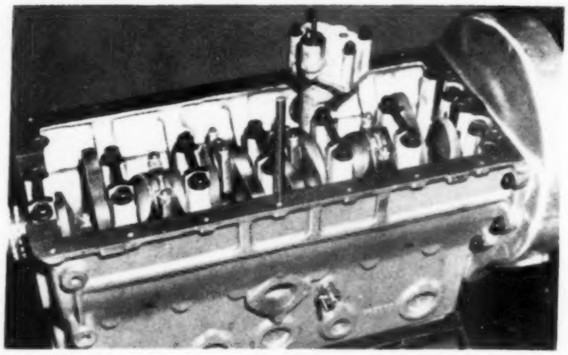
Above: The complete engine, coupled to the Borg-Warner automatic transmission. At the front of the cylinder head is the thermostat housing, and the breather for the rocker gear is mounted at the rear

Right: Reasonable accessibility is given by the Rover installation. A considerable amount of the under-bonnet space is taken up by the air filter and silencer, mounted in tandem. The radiator is of cross-flow type and its header tank is separate

a short, curved slipper faced with synthetic rubber, and its self-adjusting action is effected by engine oil pressure. Four split, plain bearings of Mazak zinc-base alloy carry the camshaft, which is a forging in En.351 steel and incorporates a spiral gear, between cylinders 4 and 5, for the vertical drive to the oil pump and the distributor. The cams have a profile of the constant-acceleration type, and they provide the following timing: inlet valve opens 17½ deg before top dead centre, and closes 40½ deg after bottom dead centre; exhaust valve opens 52½ deg before bottom dead centre, and closes 27½ deg after top dead centre.

Whereas on previous Rover car engines the cam follower levers were of the slipper type, with an arcuate surface bearing on the cam, the design was changed for the 3 Litre, to improve durability. The levers are now of manganese-bronze instead of steel, and each has a part-circular recess at the cam end. This recess is plated with Glacier lead-tin alloy, and houses a chilled cast iron roller. A spring clip at each side restricts axial movement of the roller. This roller follower arrangement was first used on the company's 2-litre diesel engine, in which it has proved very satisfactory, so its use has recently been extended to other engines.

The followers are mounted on a common shaft, but the inlet and exhaust components differ because the angle of attack is not the same in each case, nor is the method of adjusting valve clearances. Those levers that actuate the exhaust valves carry threaded adjusters at their outboard ends; the upper ends of the adjusters are hemispherical,

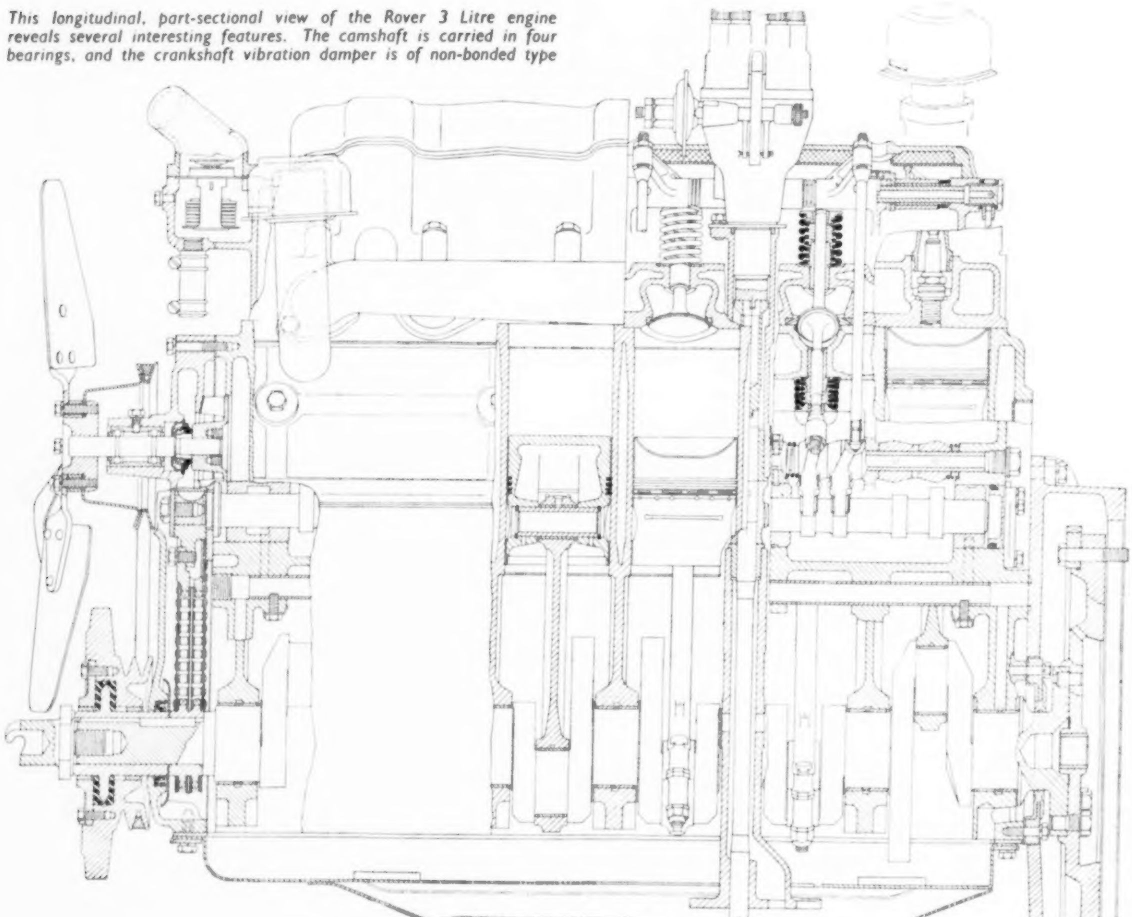


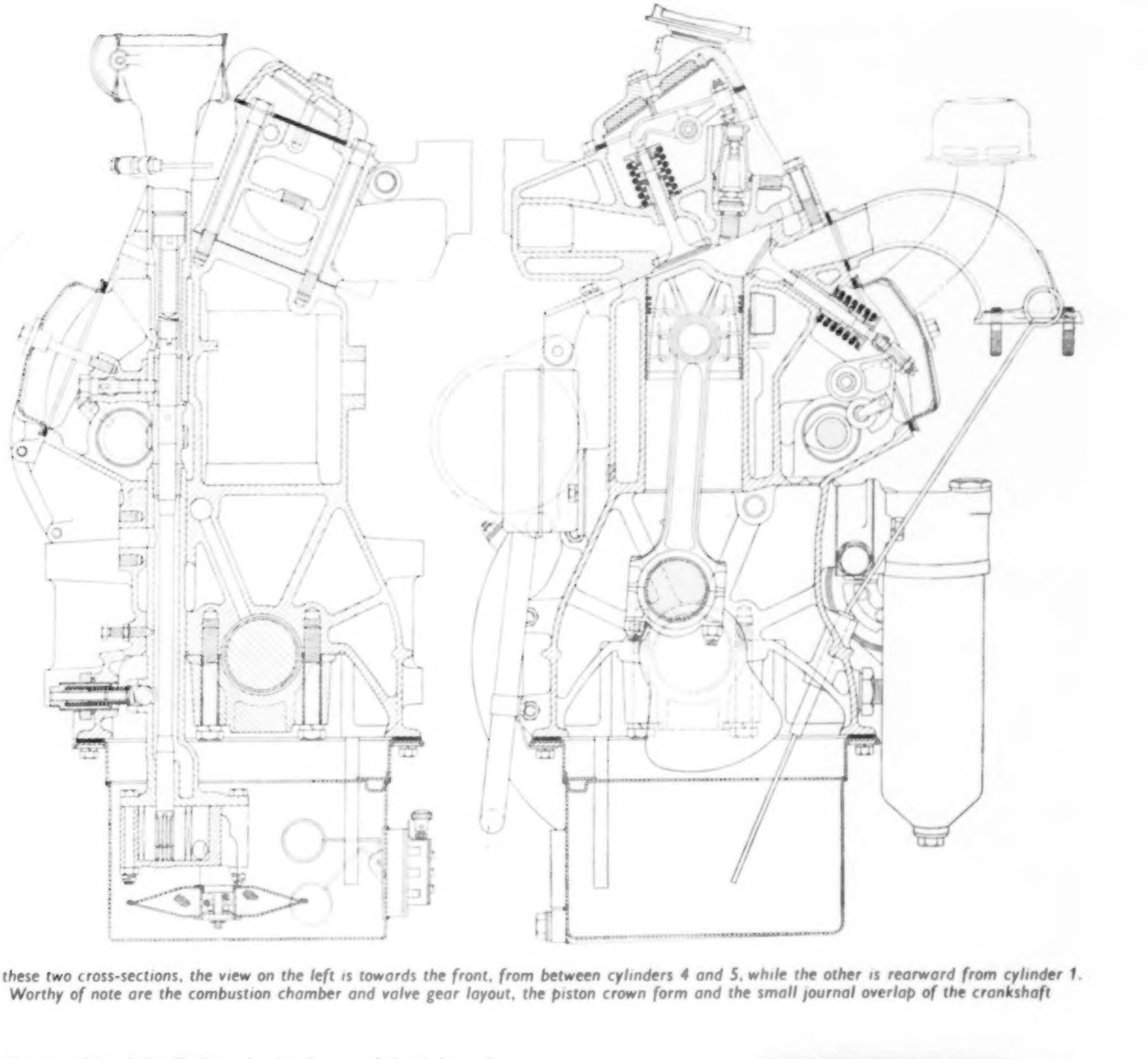
The seven main bearings of the counterweighted crankshaft have linings of copper-lead, and the iron crankcase is well reinforced internally

and on these are fitted self-aligning thrust caps, which bear on the ends of the valve stems. The other levers have hemispherical seatings for the ball-ends of the push rods, the upper extremities of which have cup-ends. In these cups seat ball-ended adjusters that are screwed into the En.32B overhead rockers actuating the inlet valves.

The exhaust valves are inclined at 55 deg to the vertical, while the inlet valves are perpendicular to the head joint face. Both sets of valves operate in cast iron guides; oil

This longitudinal, part-sectional view of the Rover 3 Litre engine reveals several interesting features. The camshaft is carried in four bearings, and the crankshaft vibration damper is of non-bonded type



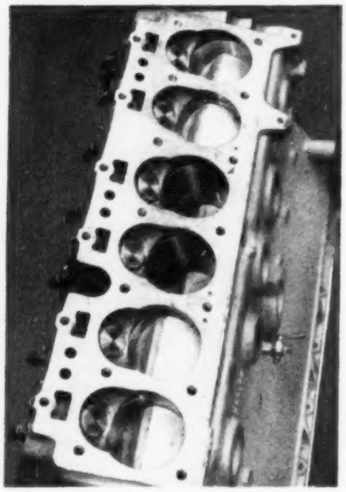


Of these two cross-sections, the view on the left is towards the front, from between cylinders 4 and 5, while the other is rearward from cylinder 1. Worthy of note are the combustion chamber and valve gear layout, the piston crown form and the small journal overlap of the crankshaft

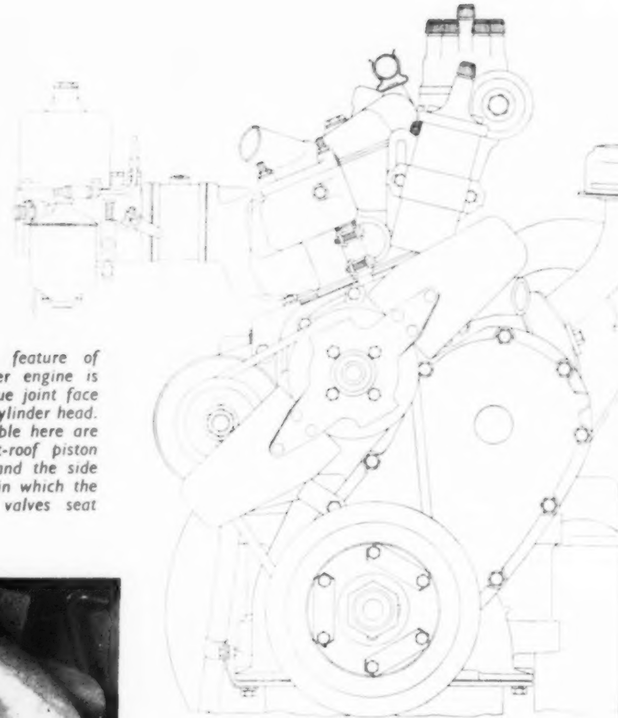
sealing is effected by O-rings in the bores of the inlet valve guides. Full details of the valves and their dual springs are given in the accompanying table of data. The valve seat inserts are pressed into the head: those for the inlet valves are of Bricromium, whereas Brimocrome is used for the exhaust seats. Both are austenitic, high-expansion cast irons. The inlet valve seats are slightly recessed into the head to give adequate clearance between the valve heads and the piston crowns; the edges of the recesses are chamfered to avoid any obstruction of the gas flow. Clearance over the exhaust valve heads at full lift is provided by cutouts of segmental shape in the underside of the cylinder head.

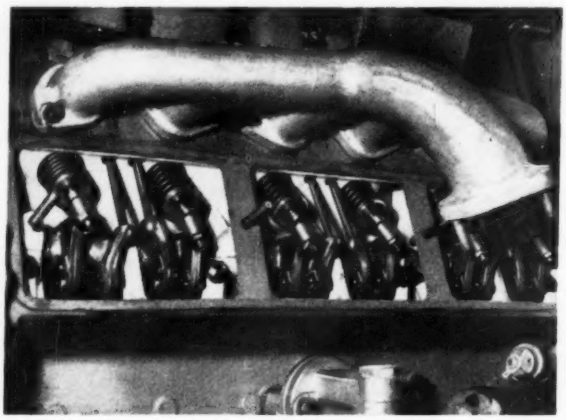
Aluminium alloy is employed for the head, the layout of which closely follows that introduced in 1949, in that the water jacketed inlet manifold is cast integrally with the head. For many years, an integral manifold has not been widely favoured, because of the resulting increased complexity of the head casting, and because of the greater difficulty in controlling the accuracy of the porting. On the other hand, it does result in some economy of weight, it eliminates a gasket and attachment means, and it obviates the possibility of malalignment of the openings at the joint face; such malalignment is not uncommon where a separate

The high camshaft is driven by a $\frac{3}{8}$ in pitch duplex roller chain. It is automatically kept in correct adjustment by a Renold type SCD hydraulic tensioner



Left: A feature of the Rover engine is an oblique joint face for the cylinder head. Also visible here are the pent-roof piston crowns and the side pockets in which the exhaust valves seat

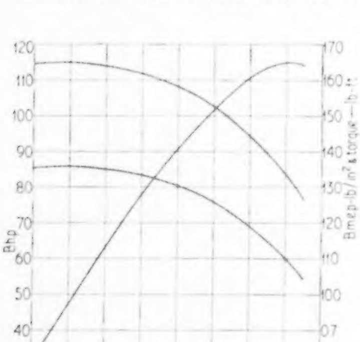




Above: Front view of the engine, showing the relatively long induction system. Left: The cam follower rollers are carried in levers, which actuate the exhaust valves and the push rods for the inlet valves

manifold is used, and can cause appreciable impairment of the breathing. From the manifold gallery, the inlet ports run almost horizontally inward until they turn downward at the valve throats.

The S.U. HD8 horizontal carburettor has a throttle barrel diameter of 2 in. Lubrication of the throttle linkage is



Curves of power, torque, b.m.e.p. and specific fuel consumption for the 2,995 cm³ engine of the Rover 3 Litre car

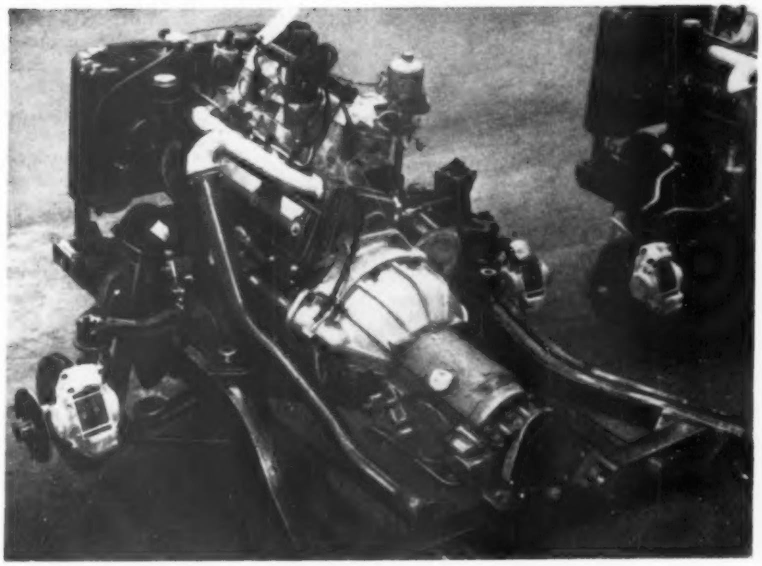
avoided by the use of nylon bushes. Fuel is supplied to the carburettor by an S.U. electric fuel pump, mounted in the boot. In the suction pipe to the pump is a solenoid valve which, in its normal position, causes a reserve of $1\frac{1}{2}$ gallons to be retained in the tank. Operation of a changeover switch on the facia actuates the solenoid and enables the reserve to be used.

Air is drawn to the carburettor through an oil-bath filter mounted in tandem with a large-capacity silencer of oval section, which is connected to the carburettor intake by a cast aluminium duct. This arrangement is typical of the company's thoroughness in the search for long life and quiet running. The six port-branch exhaust manifold is of cast iron, and its attachment face on the cylinder block is perpendicular to the head-block joint face. Efficient gas-flow is obtained by virtue of the avoidance of small-radius bends in the manifold.

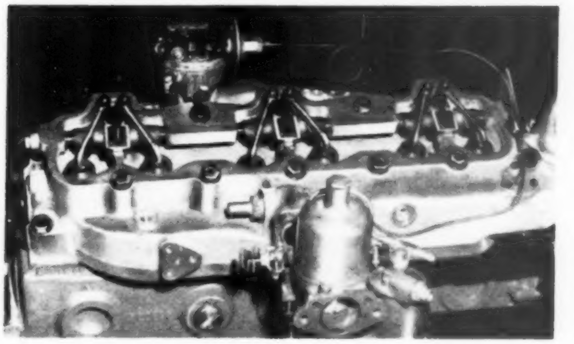
The lubrication system is orthodox, except in that there are two oil outlet holes in each crankpin, while in each connecting rod there is a jet that directs oil to the thrust side of the cylinder wall. A sump of 10 pints capacity is fitted, and a large, full-flow oil filter is mounted ahead of the starter motor, on the left-hand side of the engine. The water pump body is carried on the front wall of the cylinder block, and the impeller fits on an extension of the fan spindle. A cross-flow radiator is employed; the separate header tank is mounted behind it, on the left side. The coolant capacity is $22\frac{1}{2}$ pints, and the system is pressurized at $3\frac{1}{4}$ to $4\frac{3}{4}$ lb/in².

As is often the case on modern cars, the exhaust system is, of necessity, rather circuitous. From the off-take on the manifold, the pipe sweeps downward and rearward through a hole near the left-hand end of the rear cross member of

Right: *View of the engine and gearbox mounted on the sub-frame. The joint face of the exhaust manifold is perpendicular to that of the cylinder head, and the pipe passes through a hole in the cross member*



Below: *The inlet push rods are situated in pairs between and to the left side of adjacent cylinders. Because each inlet valve is on the transverse plane through the axis of the cylinder, the rocker arms are not at right angles to their bosses*



the sub-frame. To the rear of this member, it turns through about 120 deg towards the left side of the car, so that it is brought clear of the foot-well for the rear passengers. Under the rear seat pan, the pipe is cranked inwards, and leads into a short, longitudinally installed silencer of cylindrical form. This silencer is of straight-through type, and is alongside the left-hand rear spring, ahead of the axle. From it, an intermediate pipe sweeps over the rear axle into a downwardly inclined resonance box of circular section. The short tail pipe terminates beneath the rear bumper, towards the left-hand side.

Alternative transmission systems

The purchaser of a Rover 3 Litre has the option of either a four-speed gearbox of orthodox design, with manual control by means of a floor-mounted lever, or the familiar Borg-Warner automatic transmission. As an additional refinement, Laycock-de Normanville overdrive is available with the four-speed gearbox. It operates on top gear only, an arrangement which many people consider the most satisfactory with four ratios: if the overdrive is applied to third gear also, there is normally an inconveniently small difference between the overdrive third and direct top ratios, unless the overdrive step-up is smaller than is otherwise desirable.

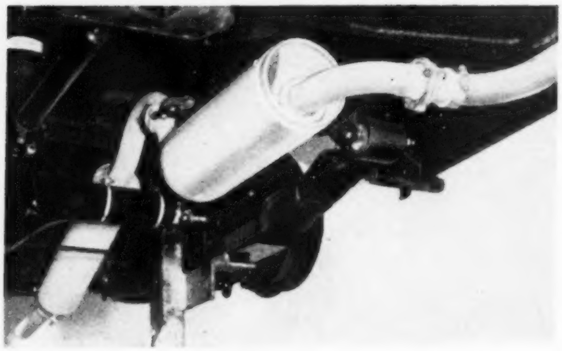
For the semi-floating, live rear axle, a ratio of 3·9 : 1 has been adopted with the automatic transmission and the manually controlled gearbox without overdrive, but if overdrive is fitted the ratio is lowered to 4·3 : 1. The step-up of the overdrive unit is 0·778 : 1, giving an overall ratio of 3·35 : 1. With the standard 6·70-15 in tyres, the road speed per 1,000 engine r.p.m. is 20·1 m.p.h. on the 3·9 : 1 axle ratio and 18·3 m.p.h. on the 4·3 : 1 ratio. When overdrive is in use, the road speed is 23·4 m.p.h. per 1,000 r.p.m.

Manually controlled transmission

When this transmission is employed, an orthodox cast iron flywheel is mounted on the rear of the crankshaft. It has a diameter of 12[illegible] in, weighs 26·4 lb and has an inertia of 670 lb-in^2. On the back of the flywheel is fitted a Borg and Beck single-dry-plate clutch of normal design. The diameter of the plate is 10 in and it has a friction area of 2×39 in^2. As on previous Rover models, the ball thrust bearing is housed within a cover attached to the front wall of the gearbox, where it is shielded from lining dust and receives lubrication from the gearbox supply. The inner race of the bearing is mounted on a sleeve, which is a sliding fit in a bush housed in the front cover, while the

VALVE DATA

	Inlet	Exhaust
Material	En.52	En.59 BRF
Head diameter	1·797 in	1·265 in
Throat diameter	1·679 in	1·147 in
Stem diameter	0·343 in	0·343 in
Diametral clearance in guide	0·0008 to 0·0028 in	
Seat angle	30 deg	45 deg
Seat material on valve	—	Brightray
Face width—on valve	0·086 in	0·105 in
on seat	0·055 to 0·035 in	0·065 to 0·045 in
Spring material	Swedish oil-tempered wire	
Spring rate—inner	81 lb/in	
outer	177 lb/in	
Spring free length—		
inner	1·703 in	
outer	1·861 in	
Spring installed length—		
inner	1·437 in	1·500 in
outer	1·562 in	1·625 in
Valve lift	0·390 in	0·444 in
Tappet clearance	0·006 in hot	0·010 in hot or cold



The requirements of adequate ground clearance and a high degree of quietness have resulted in a rather tortuous layout of the exhaust system. Mounted ahead of the rear axle is a cylindrical silencer of straight-through type, while behind the axle is a resonance chamber

outer race is free to slide within a counterbore in the cover. A scroll on the shaft obviates leakage through the bore of the sleeve.

At the front end of the sleeve is a circumferential flange, which forms the abutment for the withdrawal levers. In the engaged position, the 12 springs of the clutch exert a total thrust of 1,440 to 1,560 lb, and their combined rate is 1,500 lb/in. At the centre of the flywheel is a self-lubricating bronze bush which supports the leading end of the primary shaft.

The clutch withdrawal fork, which bears on the outer race of the thrust bearing, is splined on to its shaft. This shaft is carried in three self-lubricating bushes. Two of these bushes are on the right side and are widely spaced, to bring the outer one close to the operating lever. This latter component is hydraulically actuated so that torsional movements of the power unit are isolated from the pedal.

Since lightness of the controls is an obviously desirable feature in a car of refinement, it is of interest that an over-centre spring and linkage device is used on the Rover to reduce the clutch pedal effort. The layout of the device is clearly shown in an accompanying illustration, from which it can be seen that the lever of the over-centre mechanism is of cranked form, to permit adequate angular movement for effective operation. The inner portion of the lever, connected to the clutch actuating lever, is relatively short, while the trailing portion, on which bears the hooked link carrying the spring, has a considerably larger radius. In the engaged position, the spring provides the pull-off load necessary to bring the ends of the clutch withdrawal levers clear of the thrust bearing race.

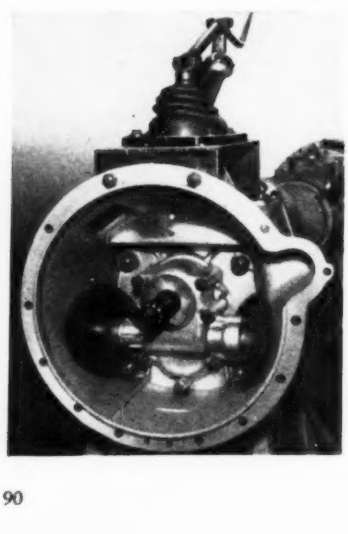
Because of the high loading on the pivot bearing of the cranked lever, this bearing is of the needle-roller type. The bearing assembly is packed with grease initially and requires no subsequent attention. This freedom from routine maintenance is obtained by effective sealing, comprising nylon lips outboard of the roller ends, and two external O-rings, which fit into grooves formed by chamfers on the pivot boss and the retaining washer.

The assistance given by the spring necessarily reduces the load available to return the fluid to the master cylinder on engagement of the clutch. For this reason, the pipeline diameter is larger than usual, and over-travel of the linkage is prevented by an adjustable stop. The efficiency of the device can be gauged by the fact that it reduces the maximum pedal effort by about a third, from 45 lb to between 26 and 30 lb.

In its essentials, the gearbox follows established Rover practice. It is of orthodox three-shaft design and incorporates baulk-ring type synchromesh engagement for second, third and top ratios, the gears of which have helical teeth. Since first and reverse gears are of the sliding engagement type, they have straight-cut teeth. All the gears are made from case-hardening nickel-chromium steel and have a pressure angle of 20 deg. Details of the materials, tooth numbers, helix angles and blank thicknesses are given in the accompanying table. A nominal centre distance of 3 in separates the mainshaft and the layshaft. The ratios are: top, 1 : 1; third, 1·377 : 1; second, 2·043 : 1; first, 3·376 : 1; reverse, 2·968 : 1.

A ball bearing, housed in the front wall of the gearbox, carries the rear end of the primary shaft, which is integral with its pinion. The leading end of the mainshaft runs on eleven $\frac{3}{4} \times \frac{1}{4}$ in rollers in the bore of the pinion. At the rear, the mainshaft is carried in a ball bearing, while the layshaft runs in a ball bearing at the front and a roller bearing at the rear. The mainshaft second and third gear pinions are freely mounted on a common, bronze sleeve. A single sliding member on the mainshaft carries the dogs for the engagement of top and third gears, and those for second gear are formed on the boss of the first-gear sliding gear. The reverse motion shaft is fixed and the idler has a phosphor-bronze bush.

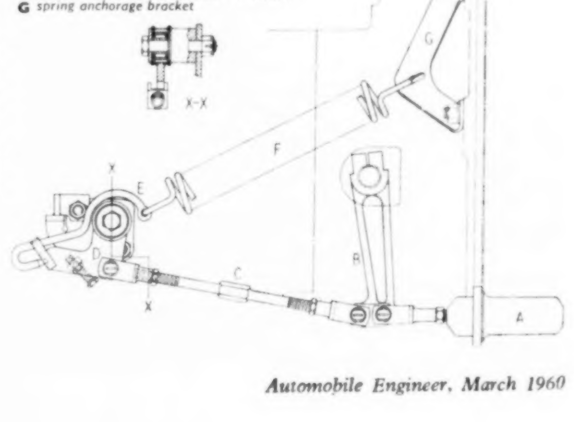
An orthodox method of gear selection is employed; the three selector rods are mounted longitudinally above the gear cluster. For the interlock, two rollers with hemispherical ends lie in a transverse hole between the rods.



Frontal view of the standard four-speed gearbox. The unusual external linkage has been employed by the company for several years: it enables the gear lever to be long yet not to encroach on the leg room of the front seat passengers

The over-centre spring device used to reduce the clutch pedal effort

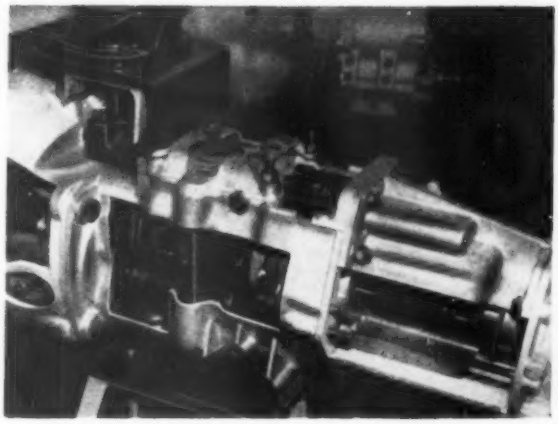
A hydraulic slave cylinder; B clutch actuating lever; C adjustable rod; D cranked lever; E spring hook; F spring; G spring anchorage bracket



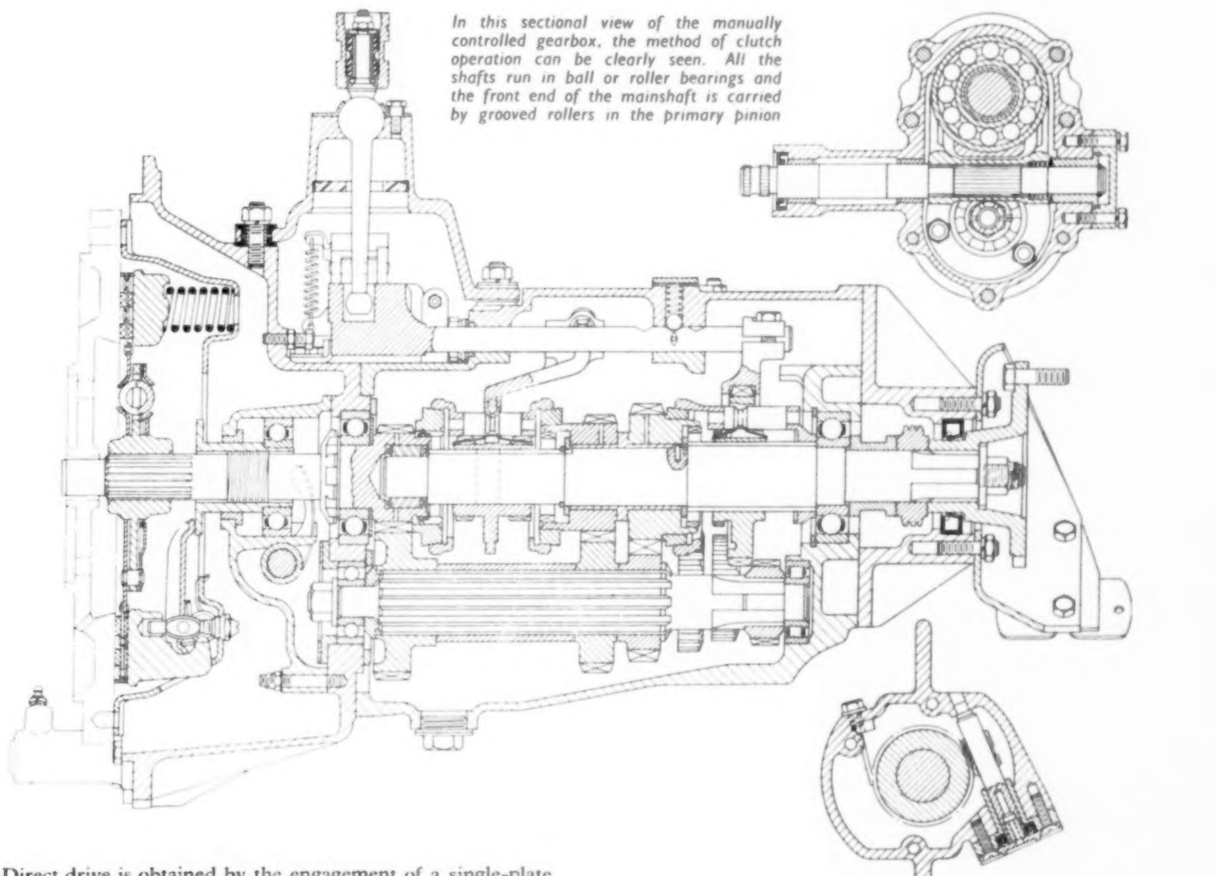
Each outer rod has a single vertical groove, of an arcuate section coresponding to the radius of the roller end, and the middle rod has such a groove on each side. The roller length is equal to the distance between the peripheries of adjacent rods plus the radial depth of one groove. A transverse hole between the grooves of the middle rod houses a plunger, the length of which is the rod diameter less the depth of one groove. Locking of the gears in the selected position is effected by the usual spring-loaded balls, which register in vee-notches in the rods. The selector forks are secured on the rods by cotter bolts.

Automatic transmission

The design and operation of the Borg-Warner automatic transmission were described in the September 1956 issue of *Automobile Engineer,* so there is no need here for more than a brief recapitulation. In essence, the transmission comprises a hydraulic torque converter in series with a two-speed epicyclic gearbox. Within the gearbox casing is a system of brake bands and a multi-plate clutch that enable reverse, low or intermediate gears to be engaged.



The four-speed gearbox is available with the Laycock-de Normanville overdrive; this operates on top gear and it gives a ratio of 0·778 : 1



In this sectional view of the manually controlled gearbox, the method of clutch operation can be clearly seen. All the shafts run in ball or roller bearings and the front end of the mainshaft is carried by grooved rollers in the primary pinion

Direct drive is obtained by the engagement of a single-plate clutch ahead of the torque converter; this engagement therefore by-passes the torque converter and gear train, and causes the gearbox output shaft to rotate in unison with the engine crankshaft. In this way, a high overall efficiency in direct drive is attained. The torque converter provides a maximum multiplication of 2·1 : 1.

Actuation of the brake bands and clutches is effected hydraulically. For this purpose there are two pumps within the gearbox, one driven directly from the engine and the other from the gearbox output shaft. The basic control is provided by a five-position hydraulic selector valve, of spool type, connected to a lever in front of the driver. On the quadrant of the lever are the indications P, N, D, L and R. The first of these is the parked position, in which the hydraulic supply is shut off and the mainshaft is locked by

GEARBOX DATA

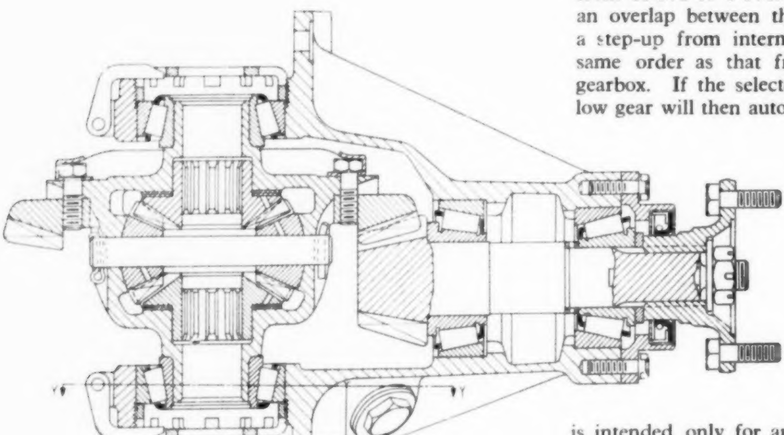
	Number of teeth	Diametral pitch	Helix angle	Material	Gear blank thickness at p.c. diameter
Mainshaft gears					
fourth	20	8·5	40 deg 14 min 11 sec	En.35A	0·875 in
third	24	8·5	40 deg 14 min 11 sec	En.35A	0·812 in
second	29	8·5	26 deg 31 min 55 sec	En.352	0·812 in
first	37	9/11	—	En.325	0·625 in
Layshaft gears					
fourth	31	8·5	40 deg 14 min 11 sec	En.35A	0·875 in
third	27	8·5	40 deg 14 min 11 sec	En.35A	0·812 in
second	22	8·5	26 deg 31 min 55 sec	En.35A	0·812 in
first	17	9/11	—	En.36V	0·687 in
Reverse idler	25 and 22	9/11	—	En.36V	0·576 in

a pawl. In the N position, the pawl is disengaged but no gear is brought into use.

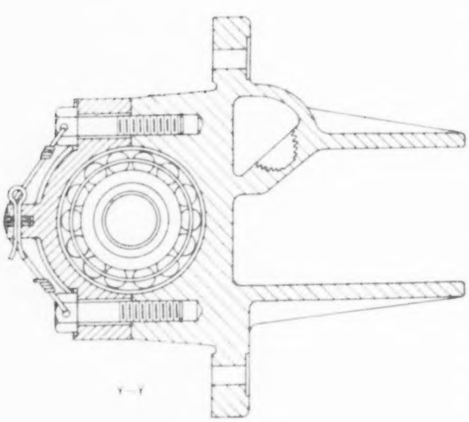
D is the normal drive position, in which the transmission operates automatically, with one exception mentioned later in this paragraph. In the version fitted to the Rover, the upward changes from a standstill are made between low, intermediate and direct ratios at speeds dependent on the throttle opening. Once direct drive has been engaged, a down-change to intermediate is only obtainable above about 20 m.p.h. by full depression of the throttle pedal, to what is known as the kick-down position. This arrangement eliminates involuntary, part-throttle changes down and so makes for greater refinement of behaviour in traffic. In the low and intermediate ratios, of course, the torque converter varies the input speed to the gear trains according to the conditions.

An additional, manual control is incorporated to provide an intermediate ratio hold, which is particularly useful when climbing tortuous inclines, or for overtaking. Should the speed exceed 60 m.p.h. with the hold in operation, a governor over-rides the control and causes direct drive to be engaged until the speed again falls below that figure. By this means, excessive engine r.p.m. are avoided.

The Rover installation provides an overall low-ratio range from 18·9 : 1 to 9·0 : 1, while the intermediate range is from 11·8 : 1 to 5·6 : 1. It will be appreciated that there is an overlap between the low and intermediate ranges, but a step-up from intermediate to direct drive of much the same order as that from third to top gear in a normal gearbox. If the selector lever is moved to the L position, low gear will then automatically be engaged. This position is intended only for an emergency, or for long and steep descents where maximum engine braking is necessary, and it should not normally be used above 40 m.p.h.



There are two rear axle ratios, to suit the alternative transmissions. Both axles have a 10-tooth pinion and are spiral-bevel units. The pinion shaft and differential cage are carried in taper roller bearings, in the conventional way



The other position of the selector lever is, of course, for reversing. By virtue of a system of electrical contacts, the engine can be started only when the selector is in the P or N setting. When the lever is in the first of these positions, the locked mainshaft will hold the car stationary on a really steep gradient. Neither parking nor reverse positions can be engaged when there is any appreciable delivery from the rear pump, that is, when the vehicle is moving forward at more than crawling speed.

Propeller shaft and rear axle

To minimize the depth of the transmission tunnel, the Hardy-Spicer propeller shaft is in two parts. Each of the three universal joints is of the conventional needle roller type; these joints are the only chassis components that require periodic lubrication. Since the intermediate universal joint is approximately below the leading edge of the rear seat pan, the rear portion of the shaft is appreciably shorter than the other. The overall diameters of the front

A rubber-insulated bracket carries the intermediate bearing of the car's divided type propeller shaft

The differential has two pinions, and the meshing of the gears is adjusted by ring nuts, one of which is visible in this view

SPECIFICATION

ENGINE: Six cylinders. Bore and stroke, 77·8 mm and 105 mm. Swept volume, 2,995 cm³. Maximum b.h.p. (gross), 115 at 4,500 r.p.m. Maximum b.m.e.p., 136 lb/in² at 1,500 r.p.m. Maximum torque, 164 lb-ft at 1,500 r.p.m. Compression ratio, 8·75 : 1. Seven-bearing, counterbalanced crankshaft. Chain driven high camshaft actuating inclined overhead inlet and side exhaust valves. Inclined joint face between cylinder block and aluminium head. Combustion chambers formed in side pockets at top of bores, bounded by pent-roof piston crowns and face of cylinder head. Water-jacketed inlet manifold cast integrally with head. S.U. single HD8 horizontal carburettor with 2 in diameter throttle barrel. S.U. electric fuel lift pump. Dry weight, 553 lb, including flywheel and clutch (with standard transmission only).

TRANSMISSION: Four-speed gearbox with manual change, or Borg-Warner automatic unit (optional extra). Borg and Beck single dry plate clutch, 10 in diameter, with standard transmission only. Manually controlled gearbox has synchromesh on top, third and second gears. Ratios: top, 1 : 1; third, 1·377 : 1; second, 2·043 : 1; first, 3·376 : 1; reverse, 2·968 : 1. Laycock-de Normanville overdrive, giving step-up of 0·778 : 1 on top gear only, available at extra charge. Torque converter range of automatic transmission, 2·1 : 1. Low gear range, 4·85 : 1 to 2·31 : 1. Intermediate gear range, 3·03 : 1 to 1·436 : 1. Dry weights: standard, 90 lb; with overdrive, 126 lb; automatic, 168 lb. Two-piece open propeller shaft with needle roller bearing universal joints. Semi-floating rear axle, with spiral-bevel reduction. Ratios: standard, 3·9 : 1; with overdrive, 4·3 : 1; automatic, 3·9 : 1.

and rear shaft tubes are respectively 2 in and $1\frac{3}{4}$ in. A ball bearing supports the rear end of the front shaft: it is carried in a housing attached to a support bracket bolted to the transmission tunnel. Rubber pads are interposed between the housing and the bracket, and between the bracket and the tunnel. The leading end of the rear shaft is connected by a splined, sliding coupling to the output spider of the intermediate universal joint.

In their general construction, the 4·3 : 1 and the 3·9 : 1 spiral-bevel rear axles are identical. A flange on the output spider of the rear universal joint is bolted to a similarly flanged member splined on to the shaft of the pinion. This shaft is carried in two taper-roller bearings in the cast iron nose piece of the axle casing. The front bearing has an outside diameter of 2·859 in, and the corresponding dimension of the other bearing is 3·125 in. A distance sleeve is fitted between the inner race of the front bearing and the flanged member, which is secured by a nut and split pin, and serves to clamp the race against a shoulder on the shaft. Adjustment of the preload on the taper roller bearings, and of the depth of engagement of the pinion, is effected by shims; these are inserted between the inner race of the front bearing and the shoulder on the shaft, and between the outer race of the rear bearing and its abutment in the nose piece. Lateral adjustment of the meshing of the gears is effected by means of ring nuts tightened against the outer races of the 3 in diameter taper-roller bearings that carry the crown wheel and differential assembly. These ring nuts also serve, of course, to adjust the preload on the bearings.

A 10-tooth pinion is common to both axles. In each, the gears are of En.35A steel and have a D.P. of 4·6. The same steel is employed for the gears of the four-pinion differential, which have a D.P. of 5: the numbers of teeth on the output and planet pinions are respectively 16 and 9. Within the differential, the planet pinions run directly on a spindle of En.36V steel, pressed into the malleable iron cage; a pin is fitted at each end of the spindle. Location of the crown wheel on the differential cage is effected mainly by means of a spigot, but two of the attachment bolts are of the fitted type.

The banjo casing is the usual steel pressing, to the rear of which is welded an end cover of 16 s.w.g. sheet steel. Two dowel pegs locate the nose piece on the banjo casing. The brackets for the rear brake compensator pivots, and for the anchorages of the rear springs and dampers, are welded to the casing. Half-shafts of the semi-floating type are fitted; they are of En.19C steel and are integral with the flanges to which the brake drums are attached. Each half-shaft tapers from $1\frac{1}{2}$ in diameter, immediately inboard of the hub bearing, to $1\frac{1}{32}$ in diameter outboard of the upset for the splines for the differential gears. Each shaft runs in a single-row, sealed ball bearing of 8 cm diameter. The outer race is pressed into a housing bolted to the end of the banjo casing, and is held against a shoulder by a sleeve into which fits the spring loaded oil seal. Pressed-on sleeves locate the inner race on the shaft, and the inboard sleeve has a ground surface on which the oil seal bears.

Mechanical Handling Exhibition

IT IS expected that this year's Mechanical Handling Exhibition, which takes place at Earls Court between the 3rd and 14th May, will be the largest and most diversified of the series. The mechanical handling industry has continued its steady growth since the previous exhibition was held in 1958, and a comprehensive selection of its products will be on view. Among those of interest to the automobile production engineer will be fork-lift trucks, cranes, conveyors of many types and electronic control equipment.

Since many of the larger types of installations are, of course, too big to put on show, they will be covered by a symposium of films. This symposium will be divided into two sections: one comprises general films on mechanical handling matters, while the other embraces films demonstrating exhibitors' own equipment.

The exhibition, which is organized by our associated journal *Mechanical Handling*, will be open from 10 a.m. to 8 p.m. on each day except Sunday, the 8th May. Full information, including the programme of the film sessions and details of travel and hotel facilities, and free admission tickets, are available from the Organizer, Mechanical Handling, Dorset House, Stamford Street, London, S.E.1.

ABNORMAL COMBUSTION

Some Phenomena Associated with the Operation of Spark-Ignition Engines with High Compression Ratios

E. M. GOODGER, M.Sc.(Eng.), Ph.D., A.M.I.Mech.E., A.F.R.Ae.S., F. Inst.Pet.*

The adoption of high compression ratios in American automobile practice has brought to light certain engine noise phenomena. Data on this subject have been presented at an S.A.E. Summer Meeting held in Atlantic City in June 1958, and at the 5th World Petroleum Congress held in New York in June 1959. These data are examined in relation to the well known problem of combustion knock.

IN the development of an engineering product, the normal process is to stress the product until failure reveals the presence of the "weakest link". Subsequent improvements in design permit further stressing until the next weak link becomes apparent. This pattern can be traced in the development of the automobile engine, and in some instances the fuel itself has been identified as the weakest link. Hence, engine and fuel development have necessarily proceeded in parallel.

One result of the incessant demand for higher performance has been a progressive rise in compression ratio, Fig. 1. This measure has enabled a correspondingly increasing amount of energy to be extracted from each pound of mixture passing through the engine, and has led to both better economy and increased power.

Stress limitations imposed by the mechanical strength of the engine can be raised, of course, by using increased bearing areas and stiffer scantlings, but certain combustion problems arise which are of major significance in respect of the continued development towards higher compression ratios. This article attempts to analyse the mechanism and effects of these interesting forms of abnormal combustion.

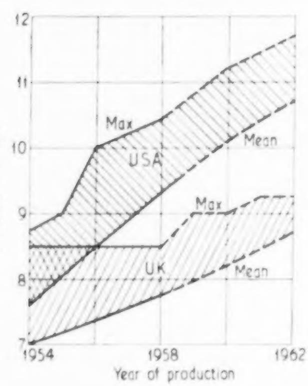


Fig. 1. Automobile engine compression ratio trends, derived from the first reference under the heading bibliography at the end of this article

Knock

The phenomenon of knock is, of course, not new, but its intensity is directly dependent upon compression ratio and, at high levels of compression ratio, it can occur in combination with other phenomena. Although there remain some discrepancies between results obtained from rig and engine tests, knock is generally agreed to be a process of spontaneous ignition within the unburnt end-gases ahead of the advancing flame front. Fig. 2 shows that, since end-gases are involved, the knock process occurs at a relatively high pressure, and leads to severe fluctuations in pressure. Intense knock causes the combustion chamber walls to vibrate in sympathy, and this gives rise to the familiar pinging sound. Sustained heavy knock leads to a general rise in operating temperature, and eventually to engine damage in the form of physical removal of metal from the piston crown. Even the highest intensity of knock occurring in an engine probably does not reach the level of a true detonation wave met in a laboratory tube-type apparatus, and the term knock is usually reserved for the engine phenomenon.

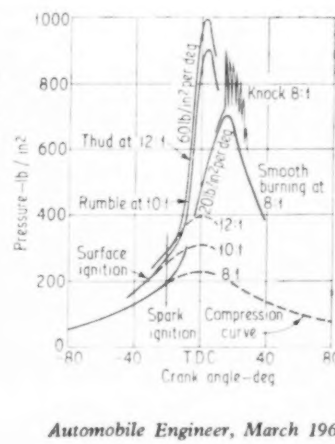
Standardized methods of anti-knock quality assessment have been developed since 1930, including methods of rating in service on the road. Precision of rating has been achieved by rigid control of test conditions, and by the use of a fuel scale, that is, matching the anti-knock performance of the sample with that of blends of reference fuels. Two paraffinic hydrocarbons, iso-octane and normal heptane, are used as upper and lower basic reference fuels respectively, and ratings are expressed in terms of octane number. Development of rating systems has led in turn to the blending of fuel with high quality components, the discovery of additives with potent anti-knock effects, and a control on the increase in the anti-knock requirement of engines, by means of improved design of combustion chambers and the use of more suitable constructional materials.

The effects upon knock of engine operating conditions are well known and are summarized in Table 1. In addition to compression ratio, ignition advance is seen to have a direct influence upon the intensity of knock.

Surface ignition and wild ping

Under normal operating conditions, ignition of the mixture in the combustion chamber is, of course, effected, near the end of the compression stroke, by means of the sparking plug. This provides a nucleus of burning gases, which

Fig. 2. Hypothetical indicator diagram, showing some typical combustion pressure effects



*Associate Professor of Engineering, Newcastle University College, Australia.

spreads throughout the chamber. At current levels of compression ratio, that is, 8 : 1, the speed of flame propagation is approximately 100 ft/sec, leading to pressure rise rates of the order of 20 lb/in^2 per deg of crankshaft rotation, and peak pressures of about 700 lb/in^2, as shown in Fig. 2. When the chamber contains hot surfaces, such as an overheated sparking plug, exhaust valve, or deposits of combustion products, local elements of mixture may be caused to ignite at instants independent of the controlled spark timing. This process occurs at relatively low pressures, Fig. 2, and leads to advanced and/or multi-flame fronts which propagate throughout the chamber by the same mechanism as the main spark-ignited flame. This phenomenon is described as surface ignition or pre-ignition.

Advanced flame fronts lead to higher temperatures and pressures earlier in the compression stroke, and greater work requirement for compression, regardless of whether the flames are induced by advanced spark-ignition or by surface ignition. Since surface ignition is not under control, a self-induced runaway condition may arise. With single cylinder test engines, the high pressures are found to cause the engine to stop, usually without damage of any sort. In multi-cylinder engines, however, the position can rapidly become serious. Each piston is forced to continue working by the action of the other pistons linked to it, and damage may result in the form of melted piston crowns and side walls, that is, a thermal failure, as distinct from the mechanical type of failure arising from sustained heavy knock. Valve heads have been known to be severed, and valve springs to be crushed, following the occurrence of severe surface ignition.

It is clear that the advanced-flame effects of surface ignition can lead to knock. Also, since knock results in a general rise in running temperature, it also increases the tendency to surface ignition: the two events are, in fact, mutually provocative. When they result in occasional sharp cracking noises, the combined phenomenon is known as *wild ping*.

Surface ignition can also occur after the spark-ignition system has been switched off. This is termed *running on* and, since it is erratic and liable to lead to a sudden reversal in rotation, it is particularly undesirable with engines having a gear-driven supercharger. The effects of operating conditions upon surface ignition are included in Table 1. Both compression ratio and ignition advance affect directly the tendencies to surface ignition, but the effects are slight.

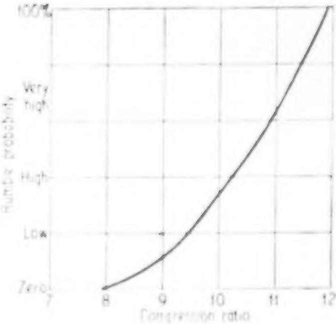
High-compression combustion phenomena

At compression ratios in the region of 12 : 1, the rates of pressure rise may become as high as 120 lb/in^2 per deg of crankshaft revolution and the peak pressure 1,200 lb/in^2. This can lead to engine noise, emanating from low frequency vibrations of components of the power train, and this is known as *thud*, or *pressure rap*. In the presence of additional flame fronts resulting from deposit-induced surface ignition, however, similar rates of pressure rise and engine noise begin to occur at much lower levels of compression ratio, that is, from about 9·5 : 1, and the phenomenon is then known as *rumble*, or *pounding*. The relationships between these various combustion phenomena are shown in Table 2.

Thud

According to Morris and Fariss[1], thud has been observed in 1958 production engines during high-speed wide-open throttle operation, as well as in engines modified to 12 : 1 compression ratio. The occurrence and intensity of thud were found to depend directly upon ignition advance, engine speed, and inlet manifold pressure, that is, throttle opening. These operating conditions conducive to thud are included in Table 1. Since, in engines, variation in fundamental flame speed with type of fuel is swamped by the accelerating effects of turbulence, thud is dependent mainly upon factors such as compression ratio and combustion chamber design, and tends to be almost independent of fuel and oil type.

Fig. 3. This curve shows rumble probability, and is from the second reference under the heading bibliography on the final page of this article



Rumble

Several 1958 S.A.E. papers provide support for the suggestion that the occurrence of surface ignition is a significant factor in the rumble process. This support is in the form of evidence of early ionization[2]; also, rumble could not be induced in a clean engine[3]. In one investigation, rumble was found to originate from piston-crown deposits, in the end-gas zone, after the main flame had progressed partially across the chamber. All rumble cycles had at least one secondary flame front[3]. Results obtained with single-cylinder test engines suggest that rumble noise is due to vibration of engine parts at a cycle time approximating to bottom dead centre position of the piston at the end of its power stroke[4]. Once started, rumble tends to continue steadily, but disappears if the deposits cease to glow[3] or are eliminated by several full-throttle accelerations[2]. With compression ratios in excess of 12 : 1, rumble persisted after many accelerations, and developed into running on and thermal failure[2].

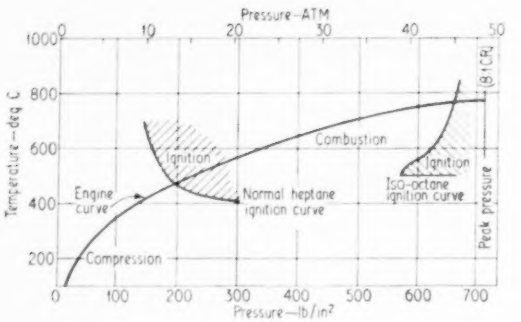
Rumble does not appear to be confined to any one particular type of combustion chamber, since it has been observed in nearly all current designs. It is more likely to occur in engines that have been used previously on light-duty traffic schedules permitting the build-up of deposits. Operating conditions conducive to rumble are included in Table 1, and the increase in the probability of the occurrence of rumble as the compression ratio is increased is shown in Fig. 3. The effect of rumble in restricting power output at high compression ratios is shown in Fig. 4.

Combustion characteristics of fuels

The general impression given by Table 1 is that all the combustion phenomena considered are promoted by similar conditions of operation. However, these events occur at different levels of pressure, as has been shown, and the

Table 1—GENERAL OPERATING CONDITIONS PROMOTING COMBUSTION PHENOMENA

Phenomenon	*Knock*	*Surface ignition*	*Thud*	*Rumble*
Compression ratio	High	High, effect slight	>12 : 1	>9·5 : 1
Engine speed	Low	Medium	High	>2,000 r.p.m.
Ignition timing	Advanced	Advanced, effect slight	Advanced	Advanced, effect slight
Manifold pressure	High	High	High	High
Mixture strength	5 to 15 per cent rich	5 to 15 per cent rich		5 to 15 per cent rich



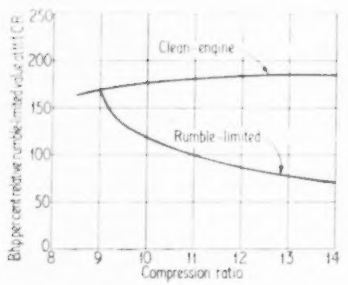


Fig. 5. Above. Temperature plotted against pressure, for conditions in an engine for spontaneous ignition, from reference 4 in the bibliography given opposite

Fig. 4. Left. Curves showing the effect of rumble in limiting power output, from the third bibliographical reference

behaviour of fuels varies widely with pressure. Fuels of high anti-knock quality, for example, are not necessarily satisfactory in resisting surface ignition.

An overall picture of the knock mechanism can be gained by comparing the temperature-pressure relationship of the mixture, in an engine combustion chamber, with the temperature-pressure conditions required for spontaneous ignition. Fig. 5 shows a typical temperature-pressure curve for the compression and combustion processes in an engine having an 8:1 compression ratio. Superimposed on this are curves showing the variation in spontaneous-ignition temperature with pressure, for both normal heptane and iso-octane, obtained by motoring an engine at very high compression ratios. The intersections of these curves with the combustion curve show clearly the order of anti-knock rating, that is, 0 and 100 respectively. This agreement between the order of intersection and the order of rating holds generally for most fuels, with and without additives, and provides support for the spontaneous-ignition theory of knock. Anti-knock quality, therefore, is dependent mainly upon the molecular structure's giving a high spontaneous-ignition temperature at high pressure.

Surface ignition, on the other hand, occurs at much lower pressures. It is affected by the temperature of combustion, in addition to the spontaneous-ignition temperature, since the combustion temperatures of previous cycles control the temperature reached by the hot surface that causes ignition. The most significant parameter in surface ignition is the difference between the temperature of the hot surface under normal operating conditions, and the temperature required for the hot surface to cause surface ignition—the latter temperature is known as the ignition surface-temperature. This parameter may be called the *hot surface-temperature differential*, and instances are found where fuels with a high ignition surface-temperature show a poor resistance to surface ignition, that is, a low hot surface-temperature differential, since their combustion temperature is also high. This point is illustrated by the curves for benzene and iso-octane shown in Fig. 6. Although benzene exhibits a high ignition surface-temperature at rich mixtures, its performance is, in fact, lower than that of iso-octane. Anti-surface-ignition quality, therefore, is dependent on both the molecular structure's giving a high spontaneous-ignition temperature at low pressure, and upon the carbon:hydrogen ratio, which controls the combustion temperature.

This indicates that the performance of fuels may be expected to compare quite differently on the bases of knock and of surface ignition. A system of rating the anti-surface-ignition quality of a fuel would permit a quantitative illustration on this point. Such a system has been devised by Downs[5], in which iso-octane and cumene are used as upper and lower reference fuels respectively. Table 3 shows Downs' octane ratings for both anti-knock and anti-surface-ignition quality. Alcohol and the aromatics, benzene and cumene, show a high resistance to knock but a poor resistance to surface ignition.

Since rumble is mainly a process of surface ignition initiated by glowing deposits, the influence of the fuel is two-fold: it depends on the tendency to form combustion deposits and the surface ignitability, the latter being indicated by the hot surface-temperature differential.

In tests for deposit tendencies, results for three fuels rated at 100 Research Octane Number with aromatic content ranging from 18 to 48 per cent by volume, showed that there is a direct relationship between aromatic content and the formation of rumble-inducing deposits. Deposits from a full-boiling alkylate were also found to be less liable to induce rumble than were those from a highly aromatic alkylate-reformate blend. A standard fuel common to all tests was used to determine rumble frequency, after the deposits had been built up with the test fuels[6]. Other tests showed that an increase in final boiling point gives rise to deposits, with an increased tendency to surface ignition and rumble[7].

In complementary tests for surface ignitability, combustion deposits were built up by using a commercial gasoline. Then, nineteen fuels rated at 100 Research Octane Number were tested, and a direct relationship was found between surface-ignition tendency and olefin content. Benzene also exhibited a marked tendency to surface ignition. Iso-

Fig. 6. These curves show the hot surface-temperatures for iso-octane and benzene, as indicated in the paper given by Downs and Pigneguy

——— *iso-octane;* — — — — *benzene*

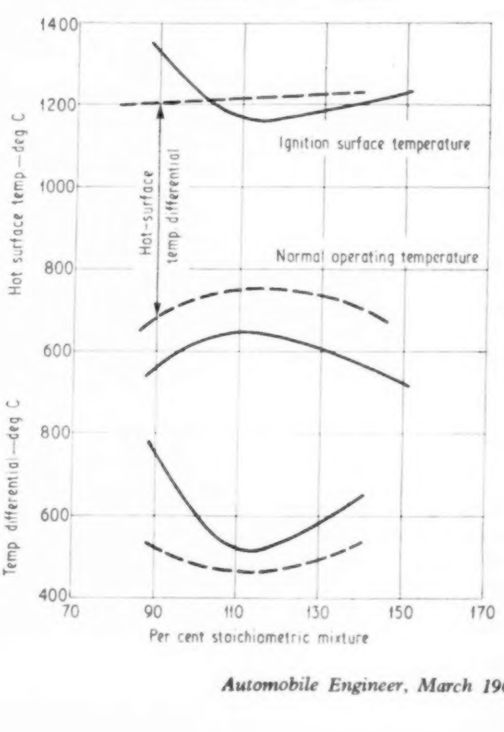


Table 2—RELATIONSHIP BETWEEN COMBUSTION PHENOMENA

Process	*Without surface ignition*	*With surface ignition*	*Noise frequency c/s*
Spontaneous ignition	Spark knock	Wild Ping	4,000 to 6,500
High rate of pressure rise	Thud	Rumble	600 to 1,400

Table 3—ANTI-KNOCK AND ANTI-SURFACE-IGNITION OCTANE NUMBERS

Fuel	*Anti-knock, motor method*	*Anti-surface-ignition, E6 engine*
Iso-octane	100	100
Methanol	112	0
Benzene	111	31
Cumene	106	0
100/130 Aviation gasoline	105	77

octane was found superior to benzene with respect to surface-ignition resistance, rumble tendency, and rumble-limited power[2,8].

Phosphorus fuel additives were found to reduce rumble effectively, even when extensive deposits already existed[6]. The addition of 0·3 theory of tricresyl phosphate raised the rumble-limited power by 25 per cent[2]. Whilst not a complete cure, this additive performs, however, a useful function.

Conclusions

In addition to an increasing anti-knock requirement, the continued trend towards higher compression ratio in the spark-ignition engine is giving rise to undesirable engine noise resulting from high rate of pressure rise. When surface ignition is not involved, at compression ratios in excess of about 12 : 1, the process is known as thud, and fuel characteristics have little effect. When surface ignition assists the high rate of pressure rise, the process is known as rumble, and fuels of a high aromatic and/or olefin content give poor performance. More rugged design of the engine is not a satisfactory solution of the problem, since this would merely mask the noise and fail to eliminate the risk of eventual runaway surface ignition. Phosphorus additives show promise of effective rumble control. There is no marked relationship between the resistance of a fuel to knock and to surface ignition. It follows that, if surface ignition becomes a major problem, fuel will need to be specified on the basis of its resistance to the two combustion phenomena, and not upon its anti-knock quality alone.

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Plating in the U.S.A.

IT APPEARS that chromium plating is as open to criticism in the U.S.A. as it is in Britain, and the efforts of the British Standards Institution and other organizations to improve the general level of quality here is paralleled by similar activities in America. At a symposium organized recently in Detroit by the American Zinc Institute, details were given of significant improvements in plating techniques. At least two companies claimed greatly increased resistance to corrosion in adverse conditions by the use of a double layer of nickel beneath the chromium.

In one of these processes, that of the Udylite Corporation, a relatively heavy first coating of semi-bright nickel is applied, followed by an overlay of bright nickel, and then the final flash of chromium. Different thicknesses of the two nickel layers are specified according to the conditions of use. Earlier difficulties of obtaining good adhesion between the layers have been overcome. It is noteworthy that one of the first major applications of this process will be to car bumpers. Because of the size and complexity of these components on many American cars, a satisfactory standard of plating is difficult to attain by earlier methods.

The representative of the International Nickel Company confirmed the view held in Britain, that buffed coatings of dull nickel gave better protection of the base metal than did fully bright nickel. Unfortunately, however, it was also more expensive, because of the hand work involved. A duplex nickel coating was much superior to a single layer of bright nickel, though the durability of the single layer was much improved by the use of an increased thickness of chromium. If copper was deposited before the bright nickel, with a normal chromium flash, the durability was greater than without the copper, but still limited.

An alternative means of increasing the service life is, of course, to improve the chromium outer layer. In this connection, mention was made at the symposium of processes recently developed by the Metal and Thermit Company. The most satisfactory of these comprised the deposition of two coatings of chromium, of which the first was of the type called by the company "bright crack-free chromium", and the second was applied under special conditions. Although the proportion of the two deposits could be varied over quite a wide range, the average thicknesses were equal. Test results had indicated that plating of this sort should have between five and ten times the life of conventional plating, and the company was convinced that a greater thickness of chromium was more important than increased nickel thickness.

The report on the symposium contains no mention of the relative costs of the normal plating methods and these duplex nickel and chromium processes. This is regrettable because higher cost has long been cited as the main obstacle to improvement in plating standards. It will be interesting to observe the effect of the new British Standard, with its specification of increased thickness of the layer of nickel.

CONTINENTAL COMMERCIAL VEHICLES

Features of Light Commercial and Similar Designs; Many Examples of Front Wheel Drive, Independent Suspension and Unitary Construction

A typical Continental light van is the Renault Estafette, which has front-wheel drive and is of unitary construction. This version is the high-top van, with a moulded, polyester-glass roof

As a generalization, it may be said that the development of the light commercial vehicle on the Continent is following lines broadly similar to that in Great Britain. The overall picture, too, shows a relatively even balance of technical merit between the products of this country and of Europe. In certain countries across the Channel, however, there is a greater concentration of effort on the smaller classes of vehicle than is the case here. Great ingenuity is shown in many such vehicles in obtaining useful interior space within small external dimensions, but the type inevitably suffers the disadvantages of relatively poor performance and short life of the highly loaded mechanical components.

Fuel tax in several countries is such that the small diesel engine, of less than 2 litres swept volume, is widely popular. As in Britain, however, it appears to be accepted that a swept volume of 1½ litres, or rather more, represents the economic minimum. Below that size, the weight excess relative to the petrol engine becomes too great in terms of reduced pay load; also, because of the rougher running of the diesel unit, the provision of an adequately robust mounting would probably necessitate an undesirable increase in the total structure weight of the vehicle.

Parallel to the British trend is the increasing tendency to enlarge the range of bodies mounted on a particular basic chassis or structure. Unitary construction is becoming markedly popular for the larger vehicles in the light commercial category, as well as for the smaller ones. Where the range of bodies is wide, though, the unitary principle of construction may not be extended beyond the basic platform and the cab.

In contrast to practice in this country, independent suspension of the rear wheels is relatively common. This fact is attributable not so much to any fundamental belief in the superiority of that layout for the vehicles concerned, but rather to the number of vehicles with front-wheel drive or rear engine layouts. The compactness of the resulting engine-transmission unit, and the saving of weight and body space attendant on the elimination of the long propeller shaft, are fully realized. In addition, with the front-wheel drive layout, the independent suspension of rear wheels is, of course, a relatively simple matter.

The Belgian F.N. Aeroporte AS24 is a small personnel carrier, powered by a 243 cm³ twin-cylinder two-stroke engine driving the rear wheels by chain and differential. Hub centre steering is an unusual feature

Austria

A remarkable project from the Steyr-Puch concern is the four-wheel-drive Haflinger, for agricultural, military and commercial purposes. The outstanding feature of this vehicle is the virtual integration of the basic structure and the mechanical components into a single unit. It would be difficult to envisage a more simple chassis frame since this consists of a large-diameter tube connecting the two drive housings and containing the transfer propeller shaft.

The engine, with its gearbox and drive assembly, is installed at the rear. It is a horizontally opposed, air-cooled, twin-cylinder unit having a swept volume of 643 cm³, and its output is claimed to be 22 b.h.p. at 4,500 r.p.m. The bore and stroke are respectively 80 mm and 64 mm, and the compression ratio is 6·7 : 1. Light alloy is employed for the cylinder heads, which contain part-spherical combustion chambers. Push rods and rockers actuate the valves from a single camshaft.

In the usual fashion for this type of unit, the bevel primary reduction of 4·22 : 1 in the final drive lies between the engine and the gearbox, which has synchromesh on all four forward ratios. There are similar differential units for the front and rear drives, and each is fitted with a lock to ensure maximum traction on slippery surfaces. Since a swing-axle suspension system is employed, the rear half-shafts have universal joints

at their inboard ends only; those at the front are of the constant velocity type. To obtain adequate ground clearance despite the small wheels, the half-shafts are higher than the wheel axes, and there is a secondary reduction, by means of spur gears, to the stub axles. This secondary reduction can be supplied with ratios of 2·38 : 1, 2·72 : 1 or 3·0 : 1, to suit different conditions of operation.

Production is simplified by employing a common layout for the front and rear suspension systems, the arrangements differing only because of the necessity of steering the front wheels. The half-shafts pass through fabricated arms of bifurcated design, which pivot on the drive casings, their axes being in line with the centres of the universal joints. Driving and braking reactions are transmitted to the spine tube by tubular drag links having rubber mountings. Coil springs form the main suspension medium but a variable rate is given on bump by double-convolution, hollow rubber springs, which are mounted coaxially within the coil springs.

The upper ends of the springs and the telescopic dampers are attached to front and rear cross members. These are sturdy, fabricated structures of approximately T-shape, rigidly attached to the drive casings. At the outboard ends of these cross members are rubber sandwich mountings for the attachment of the body. It is of interest that the engine is cantilever-mounted, on the rear end of the main tubular member of the frame, with some slight support afforded by a bracket attached to one side of the crankcase and to the body; this bracket also performs the duty of a torque reaction stay.

A transverse link connects the drop arm of the steering box to a centrally mounted slave lever, to which are attached the two pieces of the divided track rod. Brakes of 8·5 in diameter are fitted and have normal hydraulic actuation. The wheels have 12 in diameter rims and are fitted with tyres of 145 mm section.

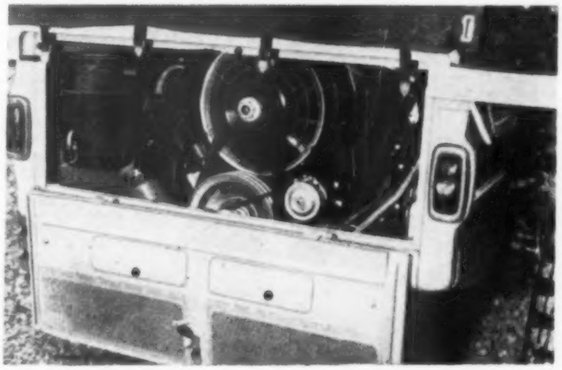
A steel floor unit, fluted for strength, is the basis of the various body types. The military and agricultural versions have simple, steel frontal panelling and a flat, two-piece windscreen. On the platform can be fitted a light, tubular structure that carries the fabric canopy and the doors. This structure is available in two forms, half-length and full-length, giving in effect pick-up and passenger layouts. The half-length version has two doors, which have tubular frames and are partially fabric covered, while the other has four doors of this same type. The pick-up model can be supplied with low side and back panels. For commercial work, a normal type of cab with a curved windscreen is being developed. The compactness of the Haflinger is indicated by its wheelbase of just under 5 ft, track of 3 ft 8½ in and overall length of approximately 9 ft 3 in. A dry weight of 11·4 cwt is quoted, and a load of nearly 8 cwt can be carried. This is a vehicle of unusual interest.

Belgium

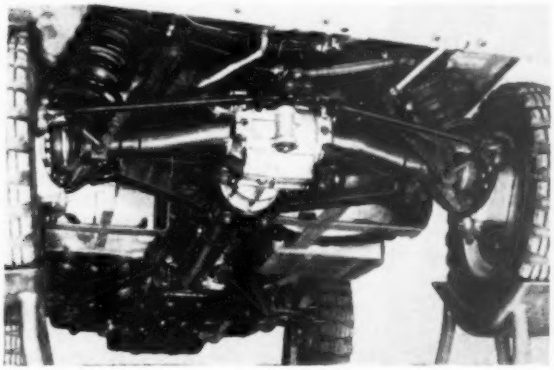
Although, apart from its motor-cycle and moped interests, the Belgian Fabrique Nationale concentrates mainly on armaments and larger commercial vehicles, it has introduced one model that falls into the category under consideration. It is the Aeroporte AS24, a small three-wheel personnel carrier intended mainly for military purposes and suitable for being dropped by parachute. There would appear to be no reason, however, why it should not also be used for non-military activities, such as in factories or on building or public works sites.

This unusual vehicle has a simple, welded frame, of which the two side members are of square section while the frontal and seat supporting structures are of circular section tubing. The frontal portion consists of a braced loop, in an almost vertical transverse plane. It is attached to the ends of the side-members, and its lower portion is interrupted in the middle, to clear the single front wheel, with its hub-centre steering arrangement. This hub-steering assembly is attached to the two ends of the tube, and control is effected by a rack-and-pinion mechanism, one end of the rack being linked to the swivelling portion of the hub. The steering column is a square section bar, and the wheel is

An outstanding cross-country vehicle of small size is the Steyr-Puch Haflinger, which has four-wheel drive and a remarkable specification. The lower picture shows the installation, at the rear, of the 643 cm³ air-cooled engine, of horizontally opposed type. To provide maximum traction in slippery conditions, both the differentials can be locked



In this underneath view of the Haflinger, the backbone tube and swing axle suspension can be seen. Rubber helper springs are fitted within the coil springs, and the hubs embody a spur gear secondary reduction



welded to it. Although it appears almost crude, the structure is robust without excessive weight.

Behind the hammock type seat is mounted the engine and transmission unit. The engine is a development of the orthodox 243 cm^3 parallel-twin, two-stroke, motor-cycle unit produced by F.N. for a number of years. Because of the shielded situation of the engine, it is cooled by a belt-driven, six-blade fan, which blows air through comprehensive jacketing on to the cylinder head and block. The engine is fitted with a single carburettor and is stated to have a maximum output of 15 b.h.p.

A four-speed gearbox forms a unit with the engine, and the final drive is in two stages. From the gearbox output shaft, an open duplex chain of $\frac{3}{8}$ in pitch drives a counter-shaft, which carries an enclosed spur gear meshing with a similar gear on the input shaft to the differential. The wheels are driven by a shaft from the differential in the usual way. A petroil mixture is carried in a tank alongside the engine, and is fed to the carburettor by pump.

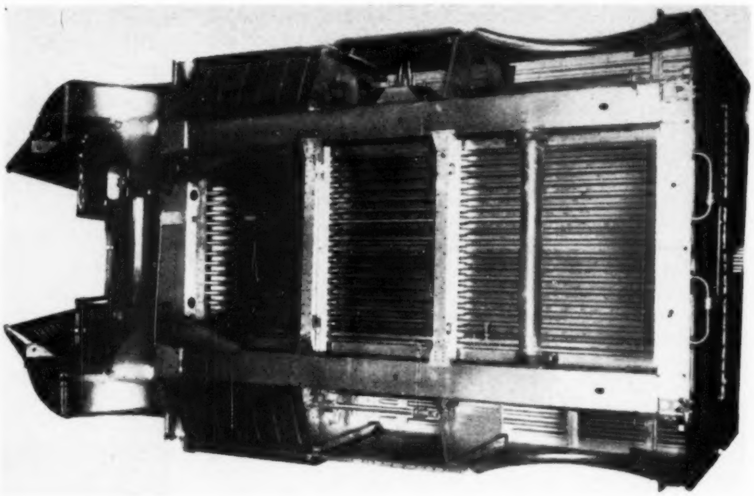
For simplicity and minimal weight, all three wheels are unsprung. To provide good traction, and to counter any tendency to sink into soft ground, the tyres have a flat, elliptical section and are mounted on very wide rims of the split type. The unladen weight of the AS24 is 175 kg, about 385 lb, and the vehicle can carry four people or a pay load of 350 kg.

France

The mechanical components and platform chassis frame of the Citroën 2CV car form the basis of two other light vehicles, a van and a station wagon. These are generally similar, with a rather box-like body structure having two rear doors for unobstructed access to the interior; the front seats, which hinge forward, are housed in what is in effect a cab, since its lines do not blend into those of the body. The body sides and the rear doors are horizontally fluted in the manner made familiar by this company.

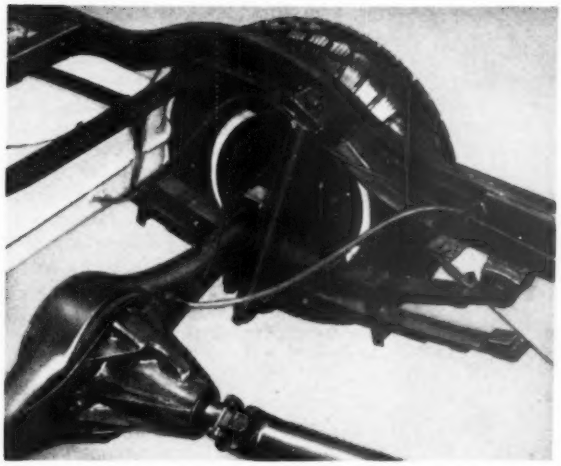
Unlike the van, which has unpierced sides, the station wagon has two large windows in the body. The rear seat is quickly removable and provides reasonable accommodation for two adults. Behind it is a considerable luggage space. The useful load of the van is just under 5 cwt. As is well-known, the 2CV vehicle is powered by a 425 cm^3 horizontally opposed air-cooled engine, driving the front wheels through a three-speed gearbox with overdrive. Its independent, four wheel suspension is of the equalizing type—dealt with analytically in the January 1957 issue of *Automobile Engineer*—and the front brakes are mounted inboard of the half-shafts. The platform unit comprises two side members, with the space between them enclosed by upper and lower panels to produce a torsionally rigid yet relatively light box type structure. Several continental coachbuilding firms have produced special purpose bodies for this chassis, one of which is illustrated.

The hydro-pneumatically suspended Citroën ID19 model, which is fitted with a 1,911 cm^3 four-cylinder engine, is marketed in ambulance and station wagon forms, both of which have a common, four-door body shell. Below the waistline, the body is virtually the same as that of the car, except at the rear, but the gently falling roof is extended rearward over the space previously occupied by the boot, to a pair of slender quarter pillars. The rear door is divided horizontally at the level of the rear lamps: the upper half,

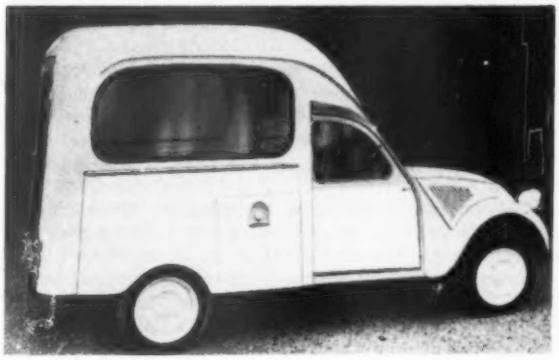


Above: Among the larger unitary vehicles are the Citroën HZ and HY ranges. Both have the same rigid under-body structure, based on two box-section longitudinals. The transverse tube, towards the rear, houses the torsion bars of the suspension system

Left: To keep tooling costs low, the only multi-curvature panels of the body shell of the HZ and HY vans are the wings and the cab roof. The front suspension is a torsion bar and double wishbone system



Above: The rear suspension of Renault's Voltigeur and Goélette models embodies full-length helper springs. Above, right: A four-cylinder 2-litre engine is fitted to the range of Citroën HZ and HY vehicles



Special bodies are sometimes fitted by Continental coachbuilders to the Citroën 2CV. This Belgian example has well rounded, flowing lines

embodying a large curved light, hinges upward to well above the horizontal position, and the lower portion opens downward.

In the ambulance version, the accommodation behind the separate front seats is for one stretcher case and one seated passenger. Since the seat folds flush with the floor, a second recumbent person could be carried, though the body width is insufficient for another stretcher of normal type. The station wagon provides seating space for up to six people on bench type front and intermediate seats, and there are two inward facing, staggered seats in the rear. These individual seats are so disposed as to give an almost unobstructed entry from the rear, and the intermediate seat can be folded into recesses in the floor, above which they do not project, to permit the carriage of bulky objects.

Of an entirely different type are the Citroën HZ and HY, forward-control models, which were designed from the start as commercial vehicles. They are basically the same, the HY being a development of the HZ vehicle and having a maximum pay load of about 29½ cwt, as against the 16·7 cwt of the earlier model. The reinforcement necessary for the heavier load, and the adoption of heavy-duty tyres, have increased the unladen weight from 25·9 cwt to 26·5 cwt.

As will be evident from these weights and the wheelbase and track dimensions of 8 ft 3 in and 5 ft 5 in, the HZ and HY are relatively large vehicles. Nevertheless, unitary construction has been adopted successfully, and full attention has obviously been given to restricting tooling costs, by keeping to a minimum the number of multi-curvature panels. As a result, the appearance, from the front in particular, is functional rather than pleasing. The underfloor structure is very robust, comprising two large-section box type longitudinal members and four transverse ones, also of box section. Of these transverse members, two are disposed at the front and rear of the longitudinals, which are relatively widely spaced, and two are intermediate. The front cross member has long gussets to the longitudinals, and the engine bearers extend forward from it. Extending laterally outwards from the longitudinals are cantilever members that support the outboard portions of the floor and are welded to the sills. The main floor panel is fluted, but a smooth panel is attached on top of it. Apart from the wings, the only major panel with multiple curvature is the cab roof; headlamps are mounted externally on the cab nose panels.

Several body styles are available, including normal vans, pick-ups, and cattle and horse boxes. Although the horse box has timber slatted sides, in the traditional manner, the body framing is of welded-up steel construction, employing mainly top-hat sections. The body sides and doors of the vans and pick-ups are horizontally fluted in the manner already mentioned in connection with the 2CV. In addition to its rear door, the standard van is equipped with a sliding door at the side.

The power unit is a low-compression version of the 1,911 cm^3 engine of the ID19. It develops 35 b.h.p. and drives the front wheels through a three-speed gearbox. All four wheels are independently sprung. The front wheels are carried on double transverse wishbones, the lower of which actuate coaxially mounted, longitudinal torsion bars. Two telescopic dampers at each side control the action of the springs—an unusual feature apparently dictated by installational requirements.

Each rear wheel is carried on a trailing arm of bell-crank form. The torsion bars are mounted within a transverse tube, which serves as an additional cross member between the frame longitudinals. Telescopic dampers are attached to the short arms of the bell-cranks and are installed almost horizontally because of the limited space between the wheels and their arches.

A relatively recent introduction by Renault is the Estafette, a vehicle that, though rather smaller, is roughly comparable with the Commer ¾-ton models reviewed in the February 1960 issue of *Automobile Engineer*. As is the Commer, this vehicle is of unitary construction and is available with a

Left: Several body types are available in the Renault Estafette range. A feature of this pick-up model is the fabric canopy. Unlike the van versions, the pick-up and light bus have a hinged door for the driver

Below: The Citroën HZ and HY also are offered with a variety of bodies. This horse box has timbered sides and tail board, but all the framing is of steel

variety of bodies, though the range is smaller than the exceptionally comprehensive one offered on the British vehicle. A major difference between the two, however, is the use of front-wheel drive for the Renault, which in turn has facilitated the employment of independent suspension of the rear wheels.

The underbody structure is orthodox, based on two full-length longitudinals and having fluted floor panels. To increase the stiffness of the otherwise unbraced roof panel of the closed models, this panel has swaging in the form of transverse channels, together with rectangular dished areas along the shoulders. The cab roof is a separate pressing, attached to the main pressing by an externally flanged joint; this joint is covered by a channel-section beading.

A sliding door on the right-hand side is a feature of the van and light bus bodies. Whereas the bus and pick-up have hinged doors to the cab, the driver's door of the van is of sliding type. On the pick-up, a normal, bottom-hinged tail-board is fitted. However, the closed models have a three-piece door to give full opening: the upper portion, embodying the rear light, hinges upward to just above the horizontal position, where it is retained by a telescopic stay; the lower portion is in two halves, hinged one at each side.

A variation of the van is the high-top model which, again like the Commer, has a deep roof of moulded, glass reinforced polyester resin, in place of the standard steel roof. The moulding is in two parts, riveted together along a transverse joint in the middle, and incorporates lateral, stiffening channels. An interesting detail is that the all-round, moulded-in gutter has a depression at each rear quarter, to provide a drain-away for rain water. Unpigmented resin is used, but the top of the roof is painted white; this arrangement permits an appreciable amount of light to reach the interior, without giving too much of a greenhouse effect in sunny weather.

The use of the Dauphine 845 cm^3 engine in a vehicle weighing about a ton unladen, and with a laden weight in the region of 33 cwt, can hardly result in a very lively performance. However, on the less congested roads of the Continent, a good power : weight ratio is less important than in Britain. In comparison with the car which, of course, has a rear-mounted engine, the power unit of the Estafette is reversed, so that the three-speed gearbox occupies the conventional position.

A double transverse wishbone arrangement is employed for the front suspension. The upper wishbones have an appreciable downward inclination in the unladen condition; they are of fabricated construction and form the lower abutment for the coil springs. Telescopic dampers are mounted coaxially within the springs. Coil springs and coaxial dampers are also used for the rear suspension. A fabricated cross member, with upswept ends, serves as the upper seat for the springs and anchorage for the dampers, and also carries the closely spaced pivots of the single, transverse wishbones that are rigidly attached to the wheel hub carriers. The suspension geometry thus gives a virtually constant track at the expense of camber variation.

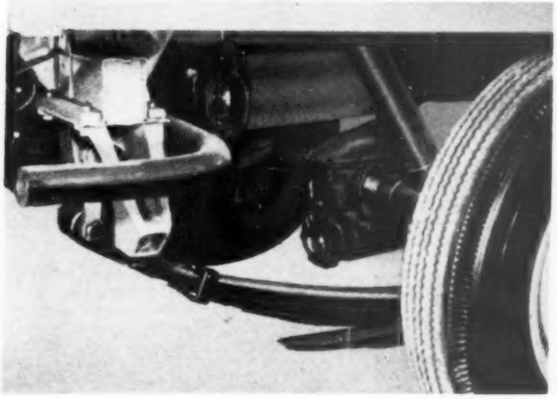
Other Renault products that just fall within the category of light commercial vehicles are the forward-control Voltigeur and Goélette ranges. The two models are generally similar but whereas the Voltigeur has a nominal pay load of 1,000 kg, or 2,205 lb, that of the Goélette is 1,400 kg. In both ranges, the same basic engine is used, that of the Frégate car but derated to suit the different conditions of operation. It is a four-cylinder unit with a stroke of 88 mm; for use in the larger-capacity vehicle, the normal bore of 88 mm is retained, but a bore of 85 mm has been adopted for the Voltigeur. The swept volumes are, therefore, respectively 2,141 and 1,997 cm^3, and the maximum power outputs are 56 and

53 b.h.p., both at 3,300 r.p.m. Torque figures of 99·4 lb-ft at 2,000 r.p.m. and 90·9 lb-ft at 2,100 r.p.m. are quoted by the manufacturers. The drive to the rear wheels is transmitted through a four-speed gearbox, open propeller shaft and spiral-bevel axle.

These vehicles have an orthodox chassis frame with splayed side members of channel-section and a central, cruciform bracing member. Semi-elliptic springs and telescopic dampers are used on both axles; the rear suspension is unusual in that the springs have the same angle of splay as the side members. Also, the helper springs are as long as the main springs, and carry a rubber pad on each end of their top leaves: these pads bear on the underside of the full-length third leaf of the main spring, when the deflection is sufficient to bring the helper springs into action. In the case of the Goélette, the main springs have nine leaves and the helper springs six. Because of its greater load capacity, this vehicle has larger-section tyres than has the Voltigeur.

Steel framework and panelling, and welded construction, are employed on all the bodies except the open version, which has timber-slatted sides and tailboard. The van is available with or without a sliding door at the side, in addition to the vertically divided rear door. Other standard versions include a high-top van and an open-side model: this latter has the sides unpanelled between the waistline and roof, though each opening is interrupted by two pillars. There is a tailboard instead of vertically hinged doors. Canvas curtains can be unrolled from the roof to cover the side and rear openings.

A rear axle of the underslung worm type is an unusual feature of the Peugeot 403 vehicles, on which the rear springs have helper leaves

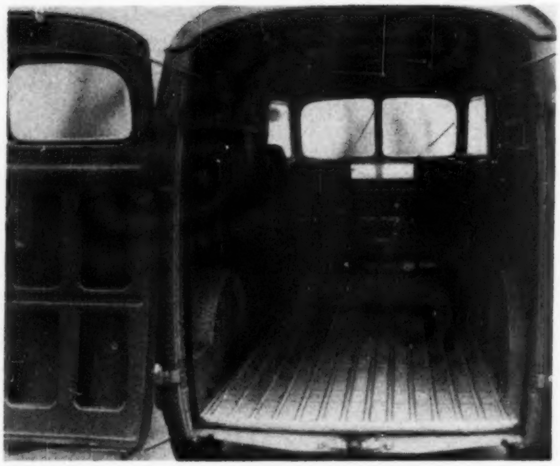


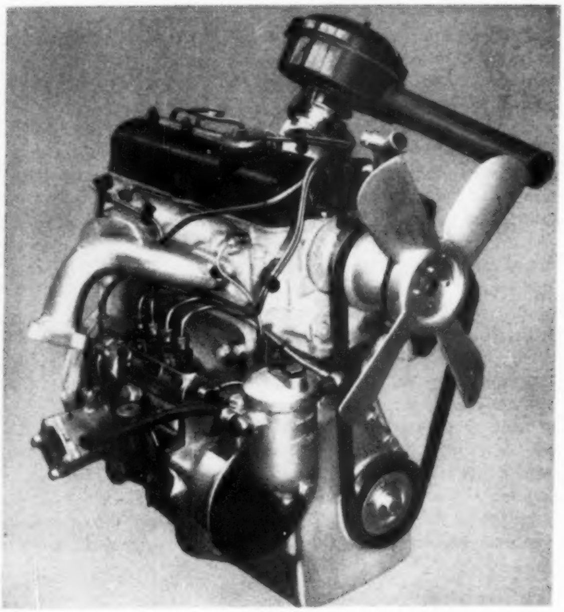
The Panhard Z.16 car forms the basis of the recently introduced F-65 range of utility vehicles, which have a maximum pay load of 12¾ cwt. Like the car, they are of unitary construction, and have the same 851 cm³ air-cooled engine, of horizontally opposed, twin-cylinder layout. The driven front wheels are suspended on two transverse leaf springs, whereas transverse torsion bars are used at the rear. There are four models in the range: a chassis and cab, van, pick-up and open truck with removable fabric top. This latter model has a body virtually identical with that of the pick-up, with the addition of the hoops for the top. In each case, the cab and front end closely resemble the corresponding portions of the car. The van has a horizontally divided rear door and is available with or without side windows.

Somewhat similar variations are made on the Peugeot 403, which is available as a station wagon, van, fabric-top open truck, and chassis with cab. Again unitary construction is employed, and the body shapes of the station wagon and van are generally similar. With the rear seat in its normal position, the station wagon has a rear platform length of 49 in, but this length can be increased to nearly 83 in by folding down the seat so that its squab forms an extension of the rear floor. If the passenger's seat is removed, as can readily be done, an object about 9 ft long can be carried. The maximum pay load of this version and the van is a little under 10 cwt, whereas that of the truck is just over 16½ cwt.

Alternative petrol and diesel four-cylinder engines are available on the 403 range. The petrol unit has a bore of 80 mm and a stroke of 73 mm, giving a swept volume of 1,468 cm³, and is similar to that of the car. Its most noteworthy feature is probably the use of part-spherical combustion chambers and inclined valves actuated by push rods from a single camshaft. Measured under the SAE specification conditions, the power output is 65 b.h.p. The diesel engine is the Indenor 85 unit, which also has over-square cylinder dimensions, 85×80 mm, giving a swept volume of 1,815 cm³. It has a five-bearing crankshaft, light alloy cylinder head, and swirl type combustion chambers; the output, based on the SAE specified test conditions, is given as 48 b.h.p. Both engines have wet cylinder liners.

Comparable in size and carrying capacity with the Citroën HY and Renault Goélette is the Peugeot D4A van, which carries a pay load of 1,400 kg. Unitary construction is employed, and all wheels are independently sprung by torsion bars. There is a choice of engines: the alternatives are a 1·5-litre petrol unit or a 1·8-litre diesel engine





Above: The lateral stiffeners of the Peugeot D4A body are of lipped top-hat section, as are the roof longitudinals; the side longitudinal members, however, are of lipped T form. Left: On the Mercedes-Benz 319 series, this 1·8-litre four-cylinder diesel engine, producing 46 b.h.p, is available as an alternative to a petrol unit of similar size

Left: One of the newer Volkswagen variants is this pick-up with a lengthened cab. It provides enclosed seating for six persons, at the expense of the space in the rear of the body. The rear seat can be removed

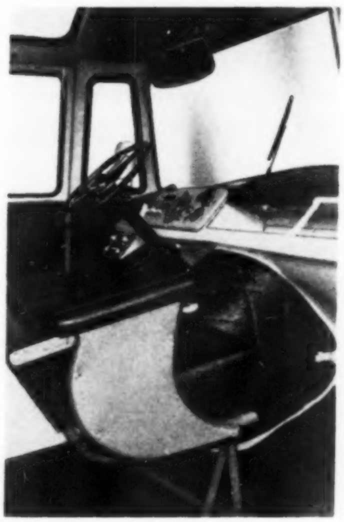
Below are two views of another new body on the Volkswagen. It is intended as an observation vehicle for special police duties. Included in its equipment are a table with inward facing seats, a wash basin, shelf and cupboard space, and a robust roof platform with access ladder

The rear axle is unusual by modern standards, in being of the worm type. It is carried on semi-elliptic springs, whereas the independent front suspension is a double transverse leaf spring and wishbone system.

A range of larger vehicles made by Peugeot, the forward-control D4A series, has the same engine alternatives as the 403 vehicles, but the transmission is modified to drive the front wheels. The D4A models are comparable with the Citroën HY and the Renault Goëlette, in that the maximum load is 1,400 kg. All four wheels are independently sprung by torsion bars. At the front they are mounted longitudinally, and the wheels are carried on double transverse wishbones, above the upper of which are the telescopic dampers. The rear suspension is of similar type to that of the Citroën: the torsion bars are housed in a transverse tube, and the telescopic dampers are installed horizontally.

Unitary construction is featured, based on two full-length longitudinal members under the floor. Although the body structure is largely orthodox, it is unusual in the use of lipped top-hat sections for the lateral stiffeners and for the longitudinal stiffeners in the roof. The longitudinal members of the sides, however, are of lipped T form; in the case of the main stiffener at waist level, the leg of the T comprises the inwardly turned flanges of the upper and lower side panels. These flanges are spot welded together.

In its normal form, the van version of the D4A model has a



The Mercedes-Benz 319 bus is noteworthy for the insulation on the outside of the engine cover, also for the unusual arm rests on the hinged front seat

sliding door at the side, in addition to the normal doors at the rear and for the cab, but an alternative has side windows and no sliding door. Other bodies, in which the same basic pressings are used, are a 12-seat light bus and an ambulance; both are noteworthy for their ample headroom. The wheelbase in each case is 7 ft 6½ in, and the front and rear tracks are respectively 4 ft 11½ in and 5 ft 2¼ in.

Germany

Since light commercial vehicles from the Borgward, Hanomag and Tempo ranges were described in the November 1959 issue of *Automobile Engineer*, they will naturally be omitted from this review, though certain details of interest are included among the illustrations. Two member companies of the Borgward group, namely Goliath and Lloyd, are producing models worthy of comment, that from the Goliath factory being the Express 1100, which carries a maximum load of a little over 18½ cwt. Although this forward-control vehicle, in its various forms, is of thoroughly modern appearance, it is one of the relatively few to have a separate chassis frame. This traditional method of construction, of course, allows more latitude than does the unitary method in the design of special purpose bodies, and it probably results in a lower cost of the bare chassis. The frame is of simple and orthodox design based on two box-section side members.

A four-cylinder, horizontally opposed engine is employed; it is liquid cooled and has overhead valves. The swept volume is 1,093 cm³, and the cylinder dimensions, 74 × 64 mm, are markedly oversquare. For a commercial vehicle engine of this size, the power output is relatively high—40 b.h.p. at 4,250 r.p.m.—but even so, the power : weight ratio is not very favourable. The drive to the front wheels is transmitted through a four-speed gearbox having synchromesh on all forward ratios.

Wishbones and a high-mounted, transverse leaf spring comprise the independent front suspension system. The rear wheels are not independently sprung: instead, an orthodox layout of beam axle and semi-elliptic springs has been adopted. Telescopic dampers control the action of both the front and rear springs.

The Express 1100 is available in six forms, one of which is the bare chassis and cab unit. There are two open trucks, one of which has an unobstructed platform floor above rear mudguard level; the other has a dropped floor, through which the wheel arches intrude. A van, a so-called Kombi and a light bus, all of similar outline, complete the range, the Kombi having a spacious, 11-seat body of station wagon type. These three bodies are noteworthy for the ease of access provided by the double doors on the right-hand side. Chassis dimensions of the Express 1100 are as follows: wheelbase, 8 ft 2½ in; front track, 4 ft 5¼ in; rear track, 4 ft 7¼ in. The overall length of the van and the other closed bodies is 14 ft 7 in.

Considering that they are powered by a 600 cm³ parallel-twin, two-stroke engine, the various Lloyd 600 vehicles are extraordinarily capacious. On the other hand, the structure weight must be sufficient to result in a decidedly sluggish performance. The platform on which the bodies are based is integrated to a single, large-diameter backbone tube, and the wheelbase is unusually long in relation to the overall length. Although, in consequence, the rear overhang is small and a satisfactory ride should be attained, a relatively heavy under-body structure is necessary for adequate beam strength.

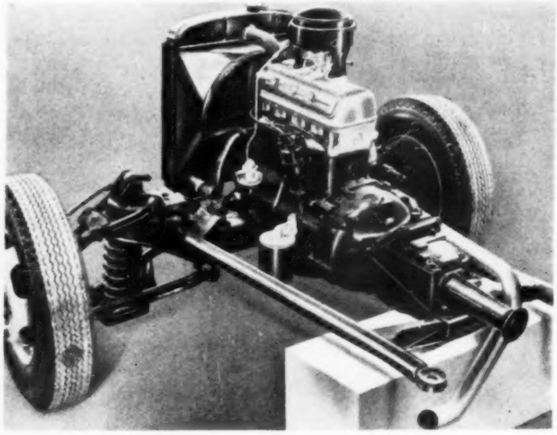
Front wheel drive is employed, and the front suspension is effected by two transverse leaf springs, one above the other. The rack-and-pinion steering gear has a conventional linkage to the front wheels. Transverse, pivoted arms of a divided axle carry the rear wheels, but the suspension is effected by longitudinal semi-elliptic springs instead of the

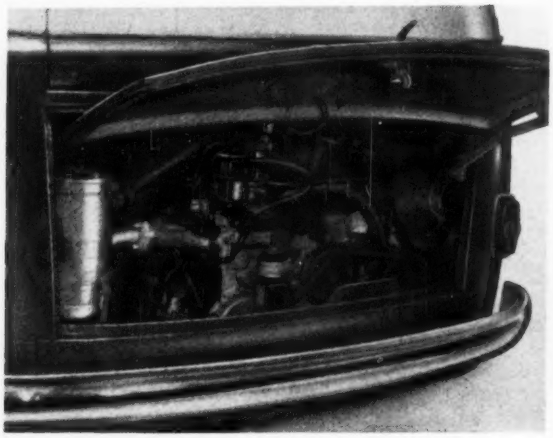
On the Hanomag Kurier and Garant, the double wishbones of the front suspension system have a small trailing angle

coil springs more common with this layout. As in the case of the Goliath, the van and the 6-seat Kombi bodies are built largely of common pressings; a pick-up body is the third available type.

The Mercedes Benz 319 models are the smallest type of commercial vehicle manufactured by this company. There is nothing unorthodox about the chassis layout: the frame is of normal design and the front and rear axles are suspended on semi-elliptic springs. Alternative petrol and diesel engines are available, both of them 1·8-litre, four-cylinder units with respective power outputs of 74 and 46 b.h.p. In addition to the chassis and cab unit, a small bus and a variety of vans are offered, one of the vans being of the insulated type for the carriage of meat or other perishable goods.

So few automobile engineers can now be unfamiliar with the fundamental layout of the Volkswagen that any description of this would be superfluous. Nevertheless, the available range of commercial and utility bodies continues to be extended. Among them, the van, dropsider, delivery float,





Top, left: A two-stroke engine of 600 cm³ swept volume is installed in the German Lloyd vehicles which, for their power, are very capacious; the example shown is the 6-seat Kombi. Top, right: On certain Borgward models, the engine and the front suspension are mounted on a sub-frame

Above, left: The four-cylinder, 633 cm³ engine of the Fiat 600 van is mounted at the rear, with the radiator alongside. Above, right: Another variant of the Fiat 600 is the Multipla taxi, which can readily accommodate four full-size passengers

The Fiat 600 van, based on the Multipla chassis, has a remarkably spacious interior for its size. Nearly the full length of the goods carrying platform is revealed on opening the two side-doors, which swing back through an angle of almost 180 deg

pick-up, ambulance, 9-seat station wagon and Microbus all follow the familiar pattern; but there are two recent additions of interest. The first of these is a pick-up with the cab lengthened to take a second bench seat, thus providing under-cover accommodation for six persons.

This is undoubtedly a useful vehicle for certain types of work, and it appears to be becoming increasingly popular on the Continent. It suffers, however, from two disadvantages in comparison with a canopy pick-up such as the Commer ¾-ton model: the stowage space in the rear is considerably restricted, and the first cost is inevitably higher. In compensation, valuable equipment of reasonable bulk can be locked in the cab with the vehicle unattended. To facilitate such storage, the second seat and the tool box beneath it are quickly removable.

The second new body was developed primarily as an observation van for police traffic-work of a special nature, but clearly has military possibilities also. It is based on the station wagon but can be regarded as a special-purpose caravan. The seats in the main compartment, behind the front seat, face inwards to a transverse, folding table, and the equipment includes a wash basin, also shelf and cupboard space for papers, refreshments and equipment. Veneered plywood is extensively used for trim and interior finishing. On the roof is a solidly built observation platform, access to which is obtained by means of a tubular steel ladder; when not in use, this ladder is stowed transversely beneath the platform and is secured by a strap.

Italy

In terms of technical progress, there is no doubt that the mighty Fiat organization, by far the largest Italian producer of commercial vehicles, is well able to hold its own with its European competitors. The Fiat Multipla, based on the rear-engined 600 car chassis described in the October and November 1955 issues of *Automobile Engineer*, is already familiar. It is now available in three versions: one is a 4- to 5-seat station wagon, and the second is a 6-seat mini-bus. In each case, the rear seat or seats can be folded down on to the floor to give an unobstructed goods space. Additionally, the squabs of the station wagon's bench seats can be lowered backwards, forming a double bed.

A relatively new addition to the Multipla range is a taxi. This is a remarkable example of *multum in parvo* since it can accommodate five adult passengers of normal size, and some luggage, without undue cramping. There is the usual glass partition behind the driver, who has an individual seat instead of the bench seat of the Multipla, to give space for luggage alongside him. Between the partition and the rear bench seat are two occasional seats with hinged squabs: these seats, as an accompanying illustration shows, can be folded forward almost completely clear of the door opening. With them in the raised position, there is adequate leg room for their occupants and those of the rear seat. In fact, the only respect in which the passenger space can be criticized is that of slightly limited headroom above the rear seat—a matter that could be remedied by extending the roof by a few inches and steepening the angle of the rear quarters of the body.

It was probably inevitable that the Fiat Multipla should form the basis of a van; like the other versions of this vehicle, it is surprisingly commodious and thoroughly practical. The body floor is flat, with very shallow sills, and is obstructed only slightly by the intrusion of the rear wheel arches. Since the rear panel is nearly vertical, there is useful additional interior space above the engine compartment.

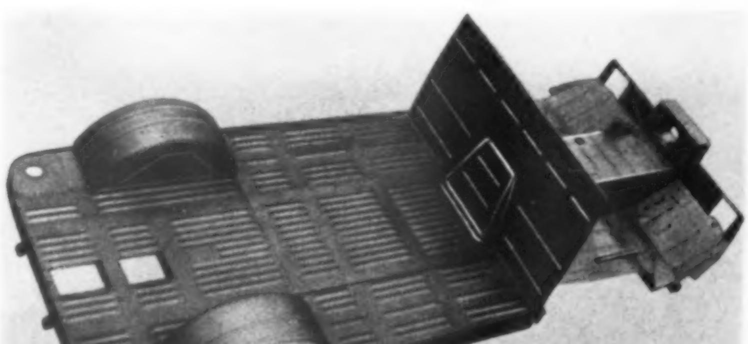
Access to the body is gained by a half-depth rear door, above the engine, and a pair of side doors, the combined width of which is almost equal to the total length of the floor. Since, in addition, the doors open through nearly 180 deg, it would be difficult to envisage a more accessible goods space. The interior of the body, including the doors and the floor, is panelled with hardboard. Though this is probably a satisfactory enough material for the side and door panels, it is unlikely to have a long life on the floor, unless protected by timber slats or a rubber or p.v.c. mat.

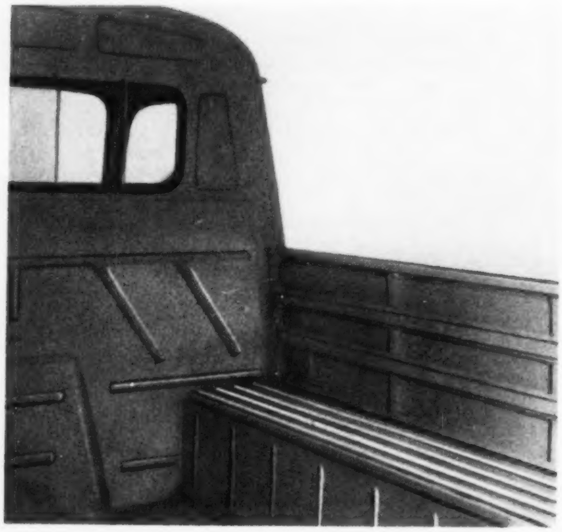
The body of this van is, of course, of unitary construction, in which respect it follows orthodox lines. To simplify production, the roof is in three parts, joined by spot welding along adjacent, inwardly turned flanges. The mid-portion extends from the rear of the cab to the rear pillar of the side doors, and is stiffened by indented, swaged panels. In addition, the edge above the door opening is internally reinforced. Swaging is employed also on the sides and doors to increase their stiffness.

Below the rear door to the body interior is a second door giving access to the engine, for routine maintenance. The panel above the engine compartment can be detached to facilitate work on the upper half of the unit, or if an engine change is necessary. Another detail of interest is the provision of a three-position adjustment for the squab of the fixed front seat. Although this adjustment cannot compensate for variations in leg length, it does enable the driver with long arms to get further from the steering wheel.

Another interesting Fiat range is the 1100T and 1100T2 series of commercial vehicles. These have not long been in production and have a maximum pay load of 21·6 cwt. The outstanding characteristics of these vehicles are forward control, rear-wheel drive, independent front suspension and unitary construction. For a forward-control layout, the

Right: All the versions of the Fiat 1100T have this unitary under-body structure, which is orthodox in design. The rear wheels are driven by a live, hypoid-bevel axle, mounted on semi-elliptic springs





This view of the pick-up body of the Fiat 1100T shows the use made of swaging to increase panel rigidity; top-hat stiffeners are widely used

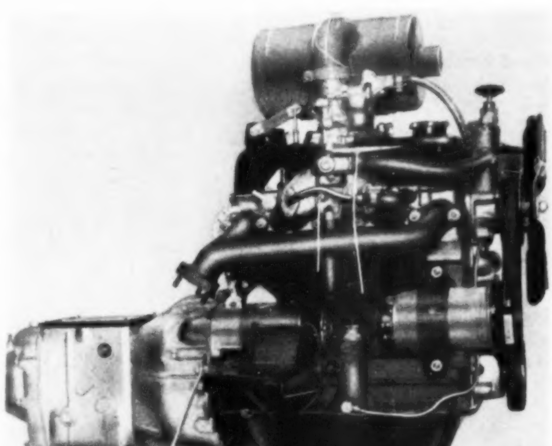
engine installation is unusually far back: only the radiator extends forward of the axis of the front wheels, and that only by a small amount.

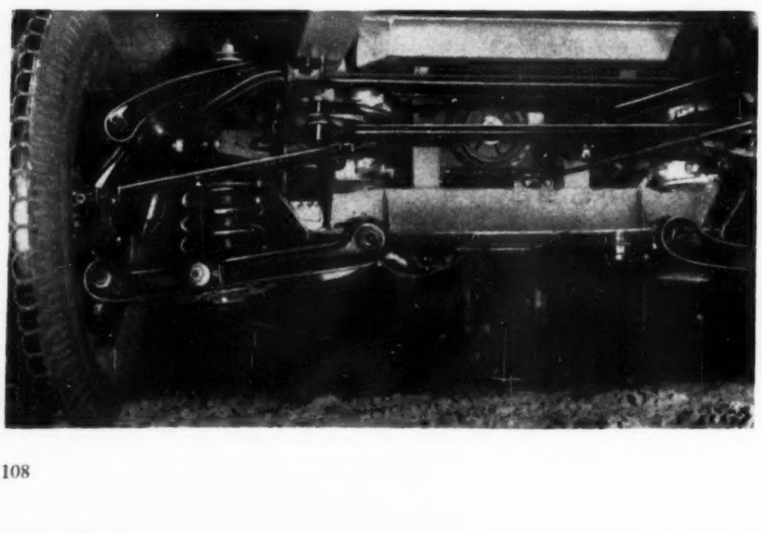
The only differences between the 1100T and 1100T2 models concern the engine and the rear axle ratio. For the 1100T, a 1,089 cm^3 four-cylinder car engine is used, in conjunction with an axle ratio of 6·43 : 1, whereas a 1,221 cm^3 unit is fitted to the other models and their axle ratio is 6·14 : 1. These two engines are similar to those used in the 1100 and 1200 cars, and have a common stroke of 75 mm; the bores are respectively 68 mm and 72 mm, and both units have light alloy cylinder heads. The compression ratio of the smaller unit is 7·0 : 1, and the net power output is quoted as 38 b.h.p. at 4,800 r.p.m. For the larger engine, the corresponding figures are 7·1 : 1 and 45 b.h.p. at 5,000 r.p.m.

As on the cars, a four-speed gearbox is fitted; it has synchromesh on second, third and top gears. The gear-change lever is mounted on the steering column, and the linkage from the gearbox is necessarily longer than is probably desirable from the viewpoint of precise control. A normal, open propeller shaft transmits the drive to the live, hypoid-bevel rear axle, which is of robust construction.

The rear axle is mounted on semi-elliptic springs, the action of which is controlled by rearwardly inclined telescopic dampers. A noteworthy feature of what is otherwise an orthodox suspension system is the incorporation of an anti-roll bar. The complete front suspension assembly is carried on a fabricated cross member, of shallow U form, bolted to the under-body structure. A slight trailing angle is given to the unequal-length wishbones: the lower wishbones are pivoted beneath the cross member, whereas the pivot spindles of the upper wishbones are carried by light alloy castings bolted to the sides of the cross member. Each casting also forms the upper abutment for the coil spring, and its cylindrical upper portion surrounds the coaxially mounted telescopic damper. A sandwich type rubber mounting is employed to attach the upper end of the damper to the casting.

Rubber bump and rebound stops are fitted. The bump stop is of deep cylindro-conical form; it is mounted on a downward-curved extension of the casting, and comes into contact with the lower wishbone. Of smaller dimensions and mounted on the upper wishbone, the rebound stop abuts against the extension casting. An anti-roll bar links the lower wishbones. The steering box is of cam and roller type, and the drop arm is linked to one of two slave levers. These levers are connected, in the normal way, by the inboard portion of the three-piece track rod. Rather surprisingly, ball joints are not employed at the outboard ends of the wishbones: instead the two stub axles swivel on king pins.





Above: The 1,089 cm^3 engine of the Fiat 1100T range is very similar to the car unit. Its bore and stroke are 68 mm and 75 mm, and the power output is 38 b.h.p. In the 1100T2 series, a 45 b.h.p. version, with the bore enlarged to 72 mm, is fitted

Left: An anti-roll bar forms part of the front suspension system of the Fiat 1100T, which is carried on a cross member bolted beneath the main structure. The dampers are mounted coaxially within the springs, and long, rubber bump stops are featured

One of the standard body types of the Fiat 1100T range is this 9-passenger bus. Other models include a van, pick-up and drop-side vehicle, as well as two forms of platform chassis, for the fitting of special bodies

The under-body structure is based on two full-length longitudinal members, side rails, and a number of cross members, all of box section. Behind the cab is a half-height, fluted bulkhead that increases the torsional stiffness of the unit. The rigidity of the portion ahead of the bulkhead is enhanced by the channel-section tunnel that leads air to the radiator. Longitudinal fluting is extensively employed on the floor panels, and the rear wheel arches form an integral part of the platform unit.

Several standard types of body are manufactured, in addition to platform chassis versions with complete or half cabs. The standard bodies include a van, with sliding side-doors, pick-up, dropsider and 9-passenger bus. In the construction of these unitary bodies, orthodox lines are followed, and considerable use is made of top-hat sections for longitudinal and transverse stiffeners. The standard van has a nominal capacity of 148 ft^3, but 186 ft^3 is actually available for exceptional loads. This vehicle has overall length, breadth and height dimensions of 14 ft 3½ in, 5 ft 10 in and 6 ft 4 in respectively. Specialist coachbuilders have fitted the chassis with, among others, ambulance, refrigerated van, mobile shop, advertising and bottle float bodies.

Plating Exhibition

IN ORDER to present full details of the new British Standard on chromium nickel plating to the plating industry and manufacturers of plated goods, The Mond Nickel Co. Ltd. held an exhibition at The Engineering Centre, Birmingham, from the 23rd to the 25th of last month. The purpose was to restore the public confidence in this form of decorative finishing. Included in the exhibition were several discussion meetings at which papers were presented, covering design in plating, the application of the British Standard, new methods of checking thickness, and details of the labelling scheme for plated articles.

Unfortunately, the announcement of the exhibition was not received until after the February issue of *Automobile Engineer* had gone to press. However, The Mond Nickel Co. will welcome any enquiries, and will be able to supply copies of the papers to those interested. Requests should be addressed to the Public Relations Officer of the company, at Thames House, Millbank, London, S.W.1.

Technical Authorship

AS a result of four years' planning by the Technical Publications Association, a syllabus for technical authorship will be introduced this spring by the City and Guilds of London Institute. Information regarding the syllabus is obtainable from the Institute, the address of which is 76, Portland Place, London, W.1. The Technical Publications Association is showing its continued interest in these examinations, by making an annual award to the leading candidate in each subject.

Those concerned with the production of technical publications may be interested in the following brief details of the Association. It was founded about seven years ago, and its principal objects are: to promote the improvement of technical publications techniques, by the interchange of knowledge; to promote and maintain a recognized status for its members; and to provide a centre for information and advice on this subject. The membership is now in the region of 300, divided into grades, and activities are sponsored by area groups in London and the provinces; there are members in various Commonwealth countries and in the U.S.A. The address of the Technical Publications Association is 46 Brook Street, London, W.1.

Filing and Classification

FOR engineering offices and libraries, a bibliography on filing, classification and indexing systems has recently been published by The Engineering Societies Library, 29 West 39th Street, New York 18, U.S.A. The references in the bibliography are to books, pamphlets and magazine articles, and the work should be of assistance to those responsible for organizing small collections of books, drawings, catalogues, papers and abstracts. There is a subject index as well as an introduction in which the selection and use of a system are discussed. The bibliography bears the reference number 14, and its price is $2.00.

Vero Auto-Drill

ALL sales matters relating to the Vero Auto-Drill are handled by Catmur Machine Tool Corporation Ltd., and not directly by Vero Precision Engineering Ltd. This machine tool is a six-spindle automatic drilling machine, with tape control by electro-mechanical means. It is particularly suitable for the drilling of such items as chassis frames, castings and plates, and can accommodate drills of up to $\frac{7}{8}$ in diameter. The address of Catmur Machine Tool Corporation Ltd. is 103 Lancaster Road, London, W.11.

Brake Fluid Contamination

*The Behaviour of Brake Fluids Containing Water, at Temperatures up to 200 deg C**

F. Jantsch

This report is based on studies of the behaviour of brake fluids containing water. Stroking test equipment, used in accordance with SAE 70 R 1, for temperatures up to 200 deg C, was employed. Changes in braking effect owing to the formation of steam in the brake system were recorded by means of a manograph. It was found that at temperatures below 150 deg C, a water content of up to 10 per cent by volume in normal commercial brake fluids has practically no effect on the braking process.

AMONG the characteristics expected of the hydraulic brake systems on automobiles, proper functioning of brakes that have become hot as a result of prolonged or repeated application is becoming increasingly important. The reason is that the ever higher road speeds and greater operating weights require more frequent and vigorous use of the brakes, which, therefore, tend to get very hot; at the same time, heat dissipation becomes more difficult because of the constant braking and the inadequate cooling that results from factors such as smaller tyre dimensions and enveloping body panels. Counter-measures to be taken for the safety of the vehicle and its passengers under these difficult conditions apply equally to the mechanical elements of the brake system and to the brake fluid, which must be adapted to the increased thermal stresses.

The first set of characteristic values for brake fluids was drawn up in the United States, and rules for testing were established. These rules, periodically modified to meet changing conditions, have for some years been included in the standard specifications of the Society of Automotive Engineers, as well as in the purchasing specifications of government agencies. These specifications, with trifling differences in some instances, are also used throughout most of Europe. In the U.S.A., brake fluids can be tested under the provisions of SAE 70 R 1 or 70 R 3, according to the expected operating conditions. Standard 70 R 3 has been in effect since 1958. It differs from standard 70 R 1 only in the values directly connected with the heating of the fluid under heavy brake stresses: as shown in Table 1, the critical values are substantially higher, or the test specifications are more rigorous.

TABLE 1

Characteristic value	SAE 70 R 1	SAE 70 R 3
Boiling point, minimum, deg C	149	190
Flash point, minimum, deg C	63	82
Stroking test:		
Number of strokes at $70\pm2{\cdot}5$ deg C and $35\pm3{\cdot}5$ atmospheres	150,000	150,000
Number of strokes at $120\pm2{\cdot}5$ deg C and $70\pm3{\cdot}5$ atmospheres	—	70,000

The most important value, so far as the behaviour of brake fluids under thermal stress is concerned, is the boiling point. If, for instance, the fluid in the master cylinder is heated above this point, which is a practical possibility if the cylinder is close to the motor and especially in operation over mountains, partial or complete evaporation of the brake fluid and failure of the brakes without warning results.

If the temperature of the fluid in the brake system reaches or exceeds the boiling point, steam pockets and vapour-lock may occur in the upper parts of the wheel brake cylinders or the feed pipes. Since steam is compressible, the operating pressure is transmitted only after a delay, or even not at all, to the brake shoes. This hazard to vehicle and passengers is a threat not only in mountain driving but also in city traffic, where the brakes may be subject to high thermal stress. In fact, constant use of the brakes, which have no chance to cool off properly in the intervals between operations, is more dangerous because vapour-lock will arise largely after the braking action is completed, and while the car is stationary, for example, waiting at traffic lights. Brake failure then catches the driver entirely unprepared.

Brake fluids containing water

To counter this threat, the application of SAE 70 R 3, as already shown, has substantially raised the boiling point for brake fluids produced in the United States. In Germany, the danger arising from brake fluids with a low boiling point is less important, because the ordinary commercial brake fluids have a sufficiently high boiling point, usually meeting the specifications of SAE 70 R 3.

The danger of brake failure exists, however, when the brake fluid that has a high boiling point has absorbed water. This water content may be the result of the natural tendency of brake fluids to absorb water from the atmosphere, or the water may have been introduced accidentally or even deliberately. Water contents as high as, or higher than, 10 per cent have been observed in practice. Contamination with water lowers the boiling point: accordingly, when the brake fluid is subjected to prolonged heating, the tendency towards vapour-lock is greater.

To determine at what temperatures and to what extent water in brake fluids produces a loss of braking effect, tests for the purpose of recording the danger limits in the use of these fluids were conducted at a proving ground of the Badische Anilin- und Soda-Fabrik AG, in Ludwigshafen on the Rhine. A stroking test apparatus was used for this purpose, and is generally employed according to the SAE specification 70 R 1, Heavy Duty.

Stroking test according to the SAE specification

This stroking test is particularly noteworthy, because it is the only one of the prescribed tests to be conducted with the brake system itself under conditions approximating to those experienced in normal operation. The apparatus is illustrated diagrammatically in Fig. 1. It consists of four standard brake assemblies with wheel brake cylinders and a master cylinder, all installed, together with the hydraulic lines, in a heated cabinet. As in a normal automobile, the

**Report from the Engineering Division of Badische Anilin- und Soda-Fabrik AG.*

lines connecting the master cylinder and wheel brake cylinders have a total length of about 15 ft. The piston in the master cylinder is actuated by a reciprocating mechanism that makes 1,000 strokes per hour. A relief valve restricts the maximum pressure to 35 atmospheres; each test is continued at 70 deg C for 150 to 300 hours.

Peak pressure and any leaks and binding of the pistons in their cylinders are noted during the test. On conclusion of the test, the condition of the rubber cups and the brake pistons, particularly in respect of abrasion, wear or pitting, and the condition of the brake fluid are carefully noted.

From the state of the components and the brake fluid, important conclusions can be drawn concerning the behaviour of the brake fluid at high temperatures, particularly as regards its sustained lubricating power and its effect on the material of pistons, cylinders and rubber cups; predictions can also be made regarding the stability of the brake fluid under conditions of prolonged and arduous operation, as well as losses through leakage or evaporation. Finally, compatibility with other brake fluids under fairly arduous circumstances can be tested with this apparatus.

Modified stroking test apparatus for temperatures up to 200 deg C

For investigation of the behaviour of brake fluids with water content and at high temperatures, the stroking test apparatus was supplemented by a device to record the pressure-stroke pattern within the brake system. The pressure diagrams thus obtained facilitated the recording and analysis of the characteristic changes in the braking process, as induced by water in the brake fluids. Among the advantages of this attachment is the fact that it can be installed easily and quickly, so it supplements at low cost the results of the stroking test apparatus.

To allow for future developments in brake fluids, it was further planned to extend the experiments up to a temperature of 200 deg C. For operation at these temperatures, the stroking test apparatus was modified in respect of the wheel brake cylinder assemblies, so that the pistons did not operate on standard brake shoes, but thrust against two bars, Figs. 2 and 3. The wheel brake cylinders are arranged one above another, inside a special heating cabinet whose temperature can be raised to 200 deg C independently of the normal equipment.

By arranging the pistons to thrust against bars, the recording of the pressures within the brake system is started at the moment when normally the brake shoe would be applied to the drum. That is, instead of operating with moving pistons, as in the usual stroking test, the travel of approximately 2 mm for the clearance between shoe and drum is eliminated and therefore is not included in the pressure curves. The chief reason for the adoption of this arrangement was the observation, in preliminary tests, that pistons of die-cast zinc bind in the wheel brake cylinders at temperatures above 150 deg C, owing to the different coefficients of expansion of the die-cast zinc pistons and cast iron wheel brake cylinders. Actual temperatures at which this binding occurs depend on the tolerances between the pistons and cylinders. Binding interferes with the consistency of the results and, at the same time, alters the conditions during the progress of the test. Furthermore, at the high temperatures and pressures, the heads of the zinc pistons bulge markedly and, again, this arbitrarily alters the test conditions. For these reasons, cast iron pistons were substituted for those of die-cast zinc. Comparison of the pressure curves obtained with fixed and movable pistons showed no difference in respect of the shape of the curves, except for the slight delay.

The pressure lines to the manograph were taken directly from the individual wheel brake cylinders. They were conducted to a distributor, through which each individual line could be connected with the manograph by way of a high-pressure valve. The manograph was an instrument manufactured by Dreyer, Droop and Rosenkranz. In it, the recording element is controlled by a tube spring. This instrument is controlled by a switch that starts and stops the paper feed at the beginning and end of each stroke, thus recording the pressure curve. The master cylinder and the feed lines were installed in the cabinet that housed the rest of the stroking test apparatus. In accordance with the specifications of SAE 70 R 1, this cabinet was maintained at a temperature of 70 deg C during the test. The entire testing installation is illustrated diagrammatically in Fig. 2, and Fig. 3 is a reproduction of a photograph.

Examples of curves showing the variation in pressure at various temperatures are shown in Fig. 4, the upper diagram of which was obtained with a brake fluid as supplied by the manufacture, that is, with 0·5 per cent water content by weight; below, is the result obtained with the same fluid but with 10 per cent water content. In each case, the pressure curve covers a stroke time of 3·6 sec, of which—depending on temperature and water content of the brake fluid—20 to 50 per cent is accounted for by the rise to peak pressure.

The pressure curve is modified when vapour-lock occurs at higher water content and temperature. As can be seen from Fig. 4, at 0·5 per cent water content the timing and shape of the curves remain practically unchanged throughout the whole range of temperature studied. The curves obtained with fluid having 10 per cent water content, on the other hand, show considerable deviations in timing and shape. Up to a temperature of 150 deg C, the only change relative to the curve obtained at room temperature is that the pressure starts to rise sooner. From 170 deg C on, however, the rise in pressure is delayed, and the peak pressure diminishes. These changes are even more pronounced at a fluid temperature of 180 deg C, while at 200 deg C there is neither a rise in pressure nor any peak pressure.

Test results

Table 2 gives test results obtained with the different brake fluids. All were tested at room temperature, also at the temperature of 70 deg C, specified for the SAE stroking test, at 100 deg C, and at intervals of 10 deg C from

Fig. 1. Diagram of the stroking test apparatus for the examination of the behaviour of brake fluids, according to SAE 70 R 1, Heavy Duty

A *drive, 1,000 rev/hr;* **B** *relief valve with overflow;* **C** *master cylinder;* **D** *thermometer;* **E** *cabinet;* **F** *feeder, total length 15 ft;* **G** *brake;* **H** *heating element*

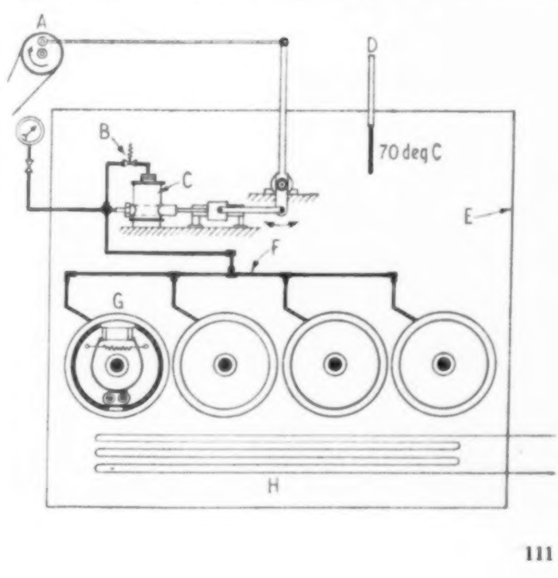


TABLE 2

Designation	Type of brake fluid	Boiling point, deg C	Water content, per cent by weight
A	Standard commercial brand	200	0·5 (as supplied) 5·0 10·0 20·0 50·0
B	Standard commercial brand	208	0·7 (as supplied) 5·0 10·0 20·0
C	Fluid containing castor oil	204	0·2 (as supplied) 5·0 10·0
D	Water	100	—

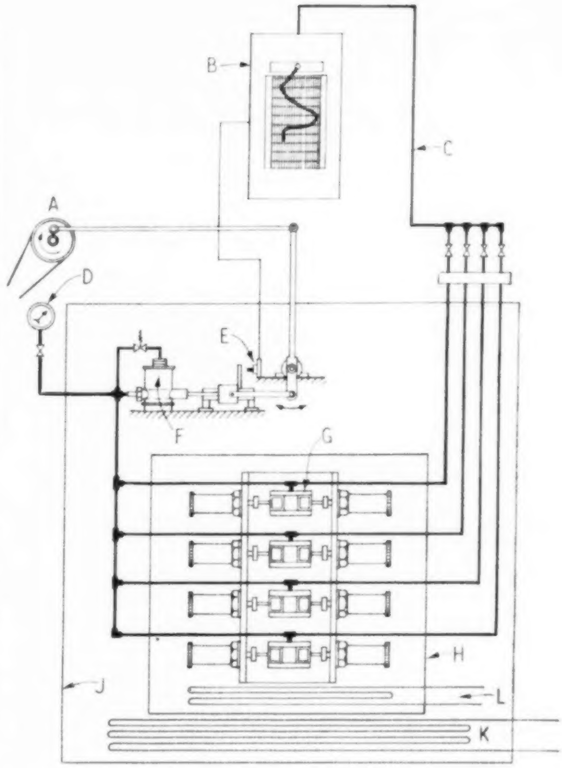
150 deg C to 200 deg C. The following characteristic values were summarized from the pressure curves for a graph of the test results:

(1) The interval from application of the brake shoes to attainment of a brake pressure of 10 atmospheres, as a characteristic indicating the reaction of the brake system

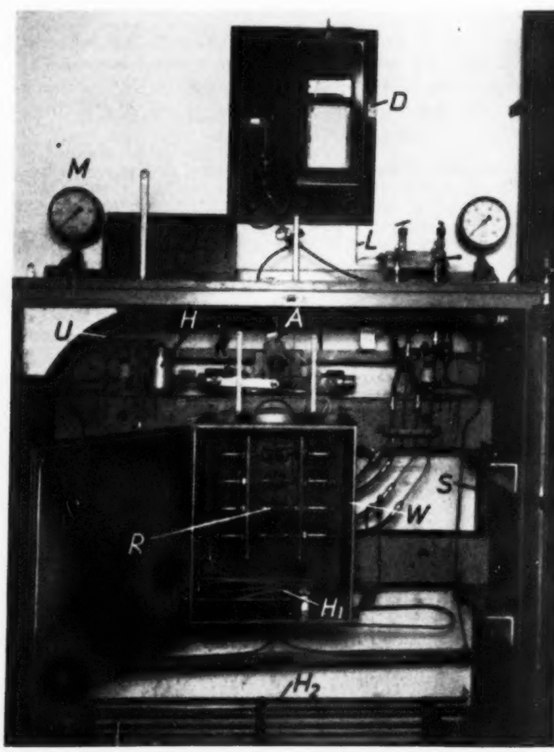
(2) The time to the attainment of peak pressure, as representative of the moment of maximum braking effect

(3) Peak pressure, in atmospheres, as an indication of the maximum braking effect.

In Figs. 5 to 7 are shown the changes in these values at temperatures up to 200 deg C, for the brake fluids as



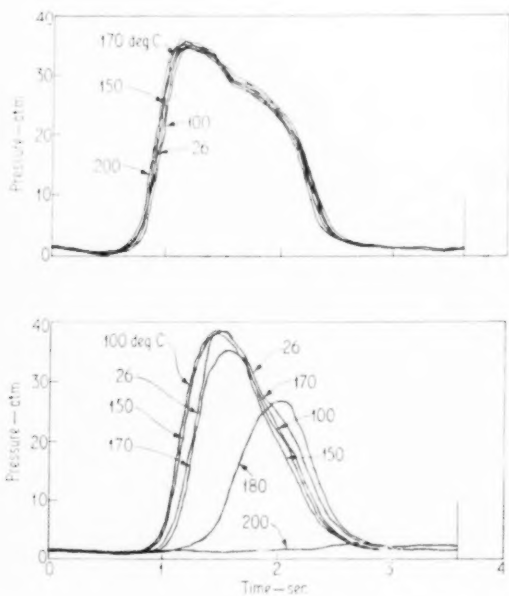
A drive, 1,000 rev/hr; B manograph; C feed line to manograph; D pressure gauge; E switch; F brake master cylinder; G wheel brake cylinder; H heating cabinet; J main cabinet; K heating element, for temperatures up to 70 deg C, for the stroking test apparatus; L supplementary heating element, for temperatures up to 200 deg C



A drive; D manograph; H brake master cylinder; H_1 heating element for the wheel brake cylinders; H_2 heating for the stroking test apparatus; K switch to activate manograph; L pressure line to manograph; M pressure gauge; R wheel brake cylinders; S main cabinet; U pressure relief valve; W heating cabinet for the wheel brake cylinders

Fig. 2, above, and Fig. 3, below, left: Stroking test apparatus with manograph and supplementary heating for temperatures up to 200 deg C

Fig. 4. Below: Pressure curves for a brake fluid—top, as supplied, that is, with 0·5 per cent water; and bottom, containing 10 per cent water



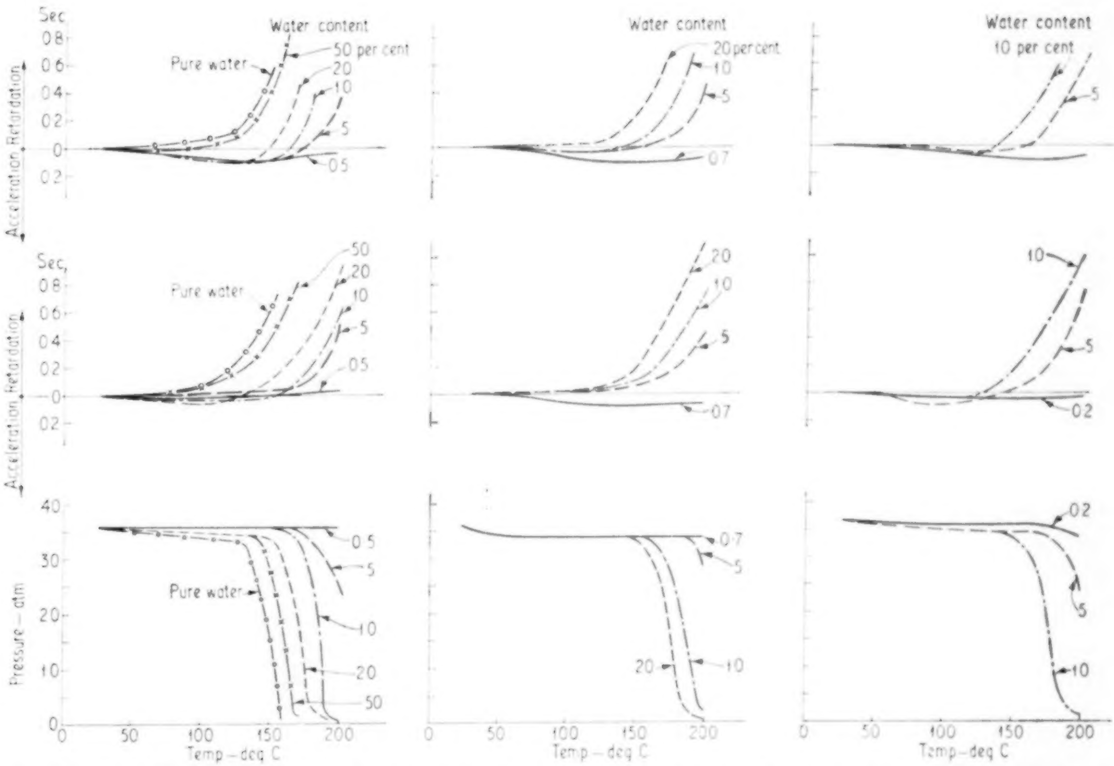


Fig. 5. Top: Effect of brake fluid temperatures on the beginning of the brake reaction. Fig. 6. Middle: Curves showing the time required for the maximum braking effect to be attained. Fig. 7. Bottom: These three curves show the effect of brake fluid temperature on the peak pressures obtained. In each of the three sets of curves, that on the left is of brake fluid A, the next is of fluid B, while that on the right is of the third fluid C

supplied by the manufacturer and with increasing water content. For purposes of comparison, the curves for the test made with pure water are also included. These graphs show that brake fluids A and B as supplied, containing 0·5 per cent and 0·7 per cent water, exhibit no loss of peak pressure up to 200 deg C, and that both the actuation time and the interval to attainment of peak pressure are shorter at the higher temperature than at room temperature. These fluids, then, would be unaffected by any heat likely to be radiated from overloaded brakes. However, in fluids that absorb water, once a certain temperature is reached, the peak pressure is reduced as the water content increases. If the temperature continues to mount, even within a short range, the peak pressure dwindles until the brake practically ceases to operate.

The temperatures at which pressure begins to fall off are also those that show a delay in braking effect, both for brake reaction and for the attainment of maximum brake pressure. Moreover, the greater the water content, the lower the temperature at which loss of pressure and delay in braking effect begin; but with these fluids the brake system remains fully effective up to a temperature of about 150 deg C, even with 10 per cent water content.

Brake fluid C, containing castor oil, proved to be substantially the same, though slightly more sensitive to high temperatures. A slight loss of pressure occurs soon after room temperature is exceeded, and the delay in braking effect with a 10 per cent water content appears at 130 deg C, which is noticeably lower than that for the other brake fluids. It is worth noting that a brake system filled with clear water shows a delay in braking effect immediately above room temperature, Fig. 5, but that the peak pressure declines so little, up to a temperature of 130 deg C, that the loss in braking effect is for all practical purposes negligible.

The critical temperatures for loss and delay in braking effect, as obtained in these tests, are useful indications of the extent to which increased water content in the brake fluid may be detrimental in a given brake system—maximum operating temperatures are usually easy to determine. Generally, in the common German commercial brake fluids, water content up to 10 per cent has no effect on braking in practical operation. On the other hand, preliminary tests indicate that the rubber gaskets and packings of the brake system, in their ordinary present-day commercial form, will give trouble at temperatures far below those that would be critical owing to water contamination in the brake fluid.

Catalyst Caps for Batteries

INFORMATION has been received regarding an interesting device that minimizes battery maintenance, and eliminates the risk of corrosion due to acid spray or of explosions resulting from gassing. This device, known as the Catylator, is fitted to the battery in place of the standard vent plug. It consists of a plastics body within which is a ceramic chamber containing a palladium catalyst. The chemical effect of the catalyst is to recombine into water the oxygen and hydrogen given off during charging. In this way, the normal loss of electrolyte is virtually eliminated, as is the possiblity of explosion of the hydrogen. Any acid spray is trapped within the cap and returned to the cell.

The Catylator is made in forms to suit most 6-volt and 12-volt batteries. It has a diameter of $1\frac{11}{16}$ in, and the height of the body, excluding the thread, is $1\frac{7}{8}$ in. Further details can be obtained from the manufacturers, Catylators Ltd., whose address is Weydown Road, Haslemere, Surrey.

DIDAS Instrumentation

System for the Recording of Measurements Taken in Vehicles Being Tested on the Road and Track

A COMPREHENSIVE system for the recording of measurements such as stresses, pressures, temperatures and movements of components, during the development testing of vehicles, has been introduced by Sir W. G. Armstrong Whitworth Aircraft Ltd., of Baginton, Coventry. It is called DIDAS, the name being an abbreviation for Dynamic Instrumentation Data Automobile System. The main advantage of this system is that the vehicle can be fitted with a large number of measuring devices and all their readings recorded simultaneously by equipment that is not carried in the vehicle; thus, provided the development programme is adequately planned, considerable savings in time can be effected and the results are not adversely affected by the installation in the car.

This has been achieved by the employment of telemetry, which is the transmission of measurements by radio or telephone line: in this particular application, the signals from the measuring devices are simply fed to a small radio transmitter in the car, whence they are passed on to a receiver in a building or other suitable set-up adjacent to the road or track. The range of the transmitter has been restricted to two miles so that problems with regard to allocation of wavebands do not arise. However, the unit can be designed to operate over a longer range.

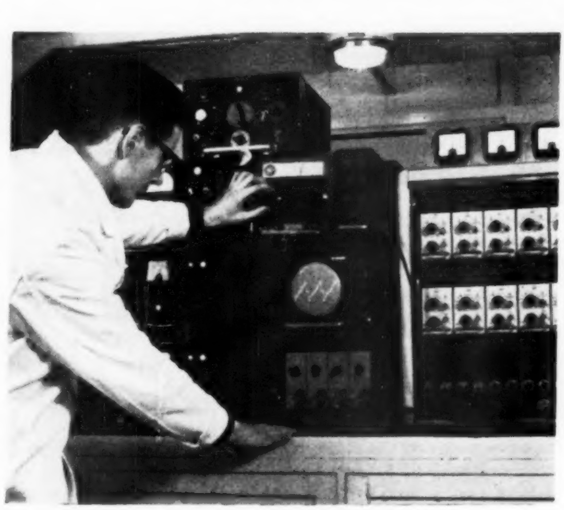
This kind of system was originally used for the testing of missiles, where it is, of course, essential because of the impossibility of carrying human observers. The reason why it was thought to be suitable for cars was that normal methods of instrumentation involve the carrying of relatively large and heavy instruments and other equipment in the car, and this affects the performance of the vehicle: for example, it is not generally possible to obtain readings for the condition in which only the driver is carried. Moreover, human limitations are such that in many circumstances, such as when travelling fast over rough terrain, it is difficult to obtain accurate readings of instruments in the car and, in any case, the number of readings that can be taken in a given time is strictly limited. With the new system, measurements are taken by observers under comfortable conditions and, provided adequate equipment is used, a large number of readings can be simultaneously recorded for analysis at leisure.

The measuring devices used are transducers for obtaining readings of strain, pressure, position, vibration or temperature. These measurements are passed to a transmitter, which weighs only 20 to 30 lb and the dimensions of which are approximately $7\frac{1}{2} \times 12 \times 15$ in. The dimensions of this unit cannot be quoted exactly because it is designed to suit the specific requirements of individual customers. An ultra-high frequency radio transmission is employed because it gives freedom from interference. The power output of the transmitter is about $\frac{1}{2}$ W and it takes about 5 or 6 amps from the vehicle battery.

At the receiving end, the signals are unscrambled. They can then be processed and the readings indicated either visually on meters, or by means of a pen recorder or on a cathode ray tube, which, of course, can be photographed, or they can be recorded on magnetic tape. When the magnetic tape is used, this can be subsequently fed to an electronic analyser: with the other methods, the analysis has to be done by an operator.

With the equipment that has been described, an analogue system is used and the results that can be obtained are accurate to within ± 3 per cent. Up to 23 different quantities can be measured simultaneously. However, very much larger numbers of readings and an accuracy of $\pm\frac{1}{2}$ per cent can be obtained if a digital system is employed. The disadvantage of this latter system is that the transmitter is considerably larger and weighs more. This, of course, would not be a serious disadvantage for commercial vehicle applications. Since the digital equipment is capable of taking 50,000 readings per sec, the only limitation on the number of measurements that can be taken simultaneously is that imposed by design considerations relating to a distributor switch for sampling these readings. Obviously, an enormous amount of development time can be saved by

These two illustrations show the transmitter used in the car under test and the static receiving equipment. The latter not only records the test results but also enables the driver to be warned, over the two-way intercommunication system, in the event of impending failure of a component that is undergoing test



the employment of this type of instrument. The reason why the digital system is so accurate is that it enables actual numbers, representing the readings, to be transmitted, whereas with the analogue system, if the signal is to be translated from, for example, a line traced by the recorder, larger errors inevitably are introduced.

So far as possible, the equipment is transistorized; this is not only for the sake of compactness but also for reliability. The design is such that failures can be readily detected and it is relatively easy to replace defective sections of the equipment. Maintenance should not be too difficult and is within the capabilities of staff normally employed on electronics work in research and development departments of vehicle manufacturers. A complete installation will cost from £2,000 to £5,000, the exact price depending upon the requirements specified by the user.

In view of the limited range of the transmitter, it is more suitable for use on test tracks than on the road. However, it could presumably be transported to, for example, a mountain pass and used there, provided the receiving equipment can be set up statically somewhere within a direct line not more than about two miles from any part of the road. Apparently, little short of a mountain between the transmitter and receiver will obstruct reception of the signals: smaller objects, such as buildings, do not have any significant effect, as has been proved by recent tests.

Tank Contents Gauge

A NEW hydrostatic tank contents gauge is manufactured by Firth Cleveland Instruments Ltd. It is of the pressure bulb type, and is stated to be suitable for measuring the head of liquid in most kinds of non-pressurized tanks, irrespective of their size and position. The indicator can be placed as far as 250 ft from the tank, and the dial can be calibrated to show either the depth or volume of the liquid. Alternative dials are available, having diameters of 4, 6, 8, or 12 in.

Comprising the gauge are separate transmitter and indicator units, together with the necessary piping and couplings. In the transmitter unit is a chamber that fills with the liquid, which applies pressure to the surface of an air-filled pressure bulb of synthetic rubber. This hydrostatic pressure is, of course, proportional to the depth of liquid above the bulb, and it is transmitted through the pipeline to the indicator. The piping is of small bore and may be of copper or nylon. Since the stiffness of the bulb has been made as low as possible, errors due to the effects of changes in atmospheric pressure and temperature on the air in the sealed system have been minimized.

The gauge can be used with any liquid that is compatible with the bulb and its housing. This housing is of cast iron, but can be stove enamelled, hot tinned or unprotected, according to requirements. Automatic high or low level alarms can be fitted or the gauge can be adapted to give automatic control of a pump, to maintain the liquid in the tank between predetermined limits. For correct calibration of the indicator, in the case of depth indication, the fluid density must be specified, whereas the tank size and shape are needed for setting it to give accurate volume readings. Enquiries should be addressed to Firth Cleveland Instruments Ltd., Stornoway Ho., Cleveland Row, London, S.W.1.

Terylene-Cotton Tarpaulin

FOR a new type of lorry tarpaulin, recently introduced by Imperial Chemical Industries Ltd., fabric woven from a Terylene-cotton yarn is employed. The yarn has a central core of Terylene, surrounded by cotton. Since the tarpaulin can be water-proofed by normal dry chemicals and wax proofings, the fabric can breathe and has a conventional appearance. According to the makers, a Terylene-cotton tarpaulin is as strong as, and lighter than, a 100 per cent flax tarpaulin, and is stronger than an all-cotton tarpaulin weighing twice as much. It provides better waterproofing, is more resistant to rotting and has good resistance to rope scuffing. Moreover, the material does not shrink when wet and dries out quickly.

Three of these new tarpaulins have been on trial by the North Western Division of British Road Services, on lorries carrying a variety of heavy loads. After ten months, they showed no sign of damage from tearing or rope abrasion, whereas cotton sheets would normally need extensive repairing after six months' use. The B.R.S. report comments on the light weight and ease of handling. Confirmation of the durability and other advantages has also been received from two road haulage firms, one of which has ordered a further eighteen tarpaulins after testing one for nine months on a lorry carrying chemicals.

So far, fabrics weighing 8 oz and 12 oz per square yard have been developed. They are regarded as suitable for replacing 12 to 18 oz and 18 to 24 oz cotton and flax fabrics. An illustrated leaflet describing the new tarpaulins is obtainable From I.C.I. Fibres Div., Hookstone Road, Harrogate, Yorks.

Ball and Socket Joints

NYLON ball joints and sockets are embodied in the tie-rod ends made by Millard Motor Accessories Ltd., Avenue Works, Pall Mall, Chorley, Lancashire. This is believed, by the manufacturers, to be the first application of nylon to both the ball and its socket, and the design has been patented in all major countries. The nylon is supplied, by I.C.I., already impregnated with moybdenum disulphide and is applied to the ball-ended pin to a thickness of 0·095 in; the cup insert is 0·1 in thick and is slightly flexible. Since the ball-ended pins are of steel with a tensile strength of 45 ton/in^2, they do not have to be hardened.

The forgings for the rod ends, as supplied, require only drilling and threading, after which the nylon insert, or cup, is placed in position and the lip of the socket peened over. Even in the unlikely event of all the nylon being worn off the ball, the diameter of the latter is still too great for it to pass through the pin aperture in the rod end-fitting. Philidas lock nuts are used for fixing. The unit is sealed with a p.v.c. grommet, and four types of heads have been found to be sufficient to cover requirements in respect of the complete range of tie-rod ends in use today.

An experimental joint, for the Land-Rover vehicle, has a spring-loaded cap so that wear of the nylon is taken up, and a small amount of extra flexibility is induced, though not in respect of shocks transmitted axially along the tie-rod. In the absence of the entry of excessive quantities of abrasives, wear of the nylon of the ball and socket is extremely small, field testing having shown 0·005 in wear after 23,000 miles; no fractures have been recorded during the eighteen months in which the tie-rod ends have been manufactured. Lubrication of the joints is unnecessary. The price is competitive, as the quotation of an example will show: model TRE108, the type for the Morris Minor, Oxford and Minor 1000, is retailed at 22s. per pair.

METAL DIFFUSION

Some Comments Relative to an Earlier Article on a Metal Diffusion Process

IN the August issue of *Automobile Engineer*, there was an article in which the Dicrom process was described; since then, we have received the following comments from Mr. R. L. Samuel, Ing, Chim., A.I.M., Director of the Metallic Surfaces Research Laboratories Ltd.

In the article on the Dicrom process, it is stated that metal diffusion is basically an interchange reaction: whilst interchange reactions do occur in several diffusion processes, they are an exception rather than the rule and, in the case of chromizing of iron or steel, interchange reaction accounts only for part of the deposition mechanism. In the case of chromizing of nickel alloys and most other metals, interchange reaction does not take place at all. These conditions are guided by the thermo-dynamic properties of the system and have been discussed in many papers or articles, among which is "Diffusion Coatings for Metals," by R. L. Samuel, Ing. Chim., A.I.M., *Metal Finishing Journal*, January 1959.

The depth of diffusion produced by the Dicrom process is stated to vary from 0·001 in to 0·015 in. This can be achieved by all chromizing processes, since high temperatures greatly accelerate the diffusion rate, but, in my opinion, coatings of over 0·010 in are hardly obtainable under commercial conditions of treatment.

I cannot understand what is meant by the surface purity of chromium, which is stated to be above 60 per cent. The concentration of chromium at the surface is entirely a function of the relative rates of diffusion and deposition, and any method of chromizing using saturation conditions of deposition, which is invariably the case, will lead to very high chromium concentration at the surface, the exact percentage depending on the temperature of treatment and the material to be diffused. In any case, unless the treatment is prolonged for a great many hours, the high chromium concentration will only prevail on a thickness of no more than 0·0001 in and will not have a great effect on the overall properties of the coating.

The statement that a chromium diffused, mild steel can satisfactorily withstand prolonged exposure to oxidation at 1,180 deg C is in direct contradiction of experimental evidence and indeed to all physical data on diffusion published to date. The rate of diffusion of chromium into iron at 1,100 deg C is such as to produce a migration in depth of 0·004 in over a period of four hours; and the equivalent figure at 1,200 deg C is nearly double. It follows that any piece of iron with a surface coating of chromium exposed to such temperatures will have a very high rate of re-diffusion, which will cause a rapid lowering of chromium concentration at the surface, with consequent increase of oxidation rate. The 40 per cent nickel/22 per cent chromium alloy mentioned in the article appears, from its composition, to be primarily a nickel alloy, rather than a steel.

The temperature of 1,305 deg C at which chromium/aluminium diffused steel can be used, is indeed staggering. The reasons quoted in the preceding paragraph apply to an even greater extent in this case, and I might mention that many manufacturers of heat resisting steels and, indeed, nickel base or cobalt base alloys, would be delighted if their material could satisfactorily perform at 1,200 deg C, let alone 1,300 deg C.

I cannot comment at length on the production of high purity chromium sheets, but it has always been possible to produce by chromizing plus long annealing, a chromium-rich iron alloy of reasonable ductility provided the thickness of the material is kept to below 0·010 in. In many cases, thin high-chromium sheets can also be produced by chemically stripping the chromized coating from its iron base.

AUTHOR'S REPLY

In answer to these comments by Mr. Samuel, the author's reply is, in effect, as follows. With regard to the interpretation of metal diffusion as an interchange reaction, it is felt that the relative numbers of instances in which interchange reactions do and do not occur would be revealing. Work by Hoar and Broom, published in *Austral. Eng.*, 1950, p 63, and *Journ. Iron and St. Inst.*, Vol. 169, 1951, p 101, and also by A. J. Sully in a work entitled "Chromium", published in 1954 by Butterworth Scientific Publications Ltd., shows that of the total chromium uptake, more than 60 per cent can be supplied by the interchange reaction. Also, with Dicrom diffusion of most nickel-chromium alloys, interchange takes place to a limited but variable extent.

If the application of an 0·015 in depth of diffusion is economically justified for a particular application, this can be obtained by the Dicrom process, under commercial conditions of operation and without recourse to extremely elevated temperatures. An explanation in respect of the surface purity of chromium is given on p 208 of the publication, by A. H. Sully, already mentioned. Additional information on this subject can be found in an article by C. Wagner and V. Stein in *Z. Phys. Chem.*, Vol 192, 1943, p 129, and in another by P. Galmiche in *Rev. Metall.*, Vol 47, 1950, p 192.

Dicrom chromium sheet is produced in an extremely ductile condition, without recourse to long periods of annealing. The chemical stripping of a chromized coating from an iron base is an expensive and inferior alternative. If chromium and aluminium are simultaneously diffused, then oxidation resistance at 1,305 deg C cannot be obtained —this is because of migration of the aluminium. However, the process referred to entails diffusion of chromium followed by diffusion of aluminium. An aluminium-saturated chromium alloy surface is produced which, on exposure to oxidizing conditions, results in the formation of a stable, adherent surface of aluminium oxide and chromic oxide, and this withstands the temperatures quoted. With regard to nickel-base alloys not being capable of performing satisfactorily above 1,200 deg C, literature on the American alloys such as Chromel P and types 309 and 406, show that resistance at temperatures higher than 1,300 deg C is possible.

Experiments with Dicrom chromium-diffused steel under conditions of oxidation at 1,180 deg C, and studies of the changes in weight relative to time of exposure, have shown that prolonged exposure is practicable. Migration in depth of 0·001 in per hour has certainly not been found.

Computers in Highway Design

AN INTERESTING new application of the electronic computer in the U.S.A. is to the design of highways. According to The Institution of Civil Engineers, the use of a computer played an important part in the recent completion in under 20 weeks of the complete detailed design of 11·2 miles of dual-carriageway road for the Indiana State Highway department in the United States of America.

SHRINK-FITTING MACHINE

A Novel Automatic Machine for Shrinking Starter Ring Gears on a Range of Flywheels

AN automatic shrink-fitting machine was recently installed in an assembly plant of an American manufacturer of goods- and passenger-carrying vehicles. It is used for shrinking a starter ring gear to flywheels of five different types. Termed the Ther-Monic, the machine was designed and built by the Induction Heating Corporation, of Brooklyn, N.Y., and constitutes a new approach to the induction heating and fitting of ring gears. It occupies only 54 ft^2 of floor area and is capable of producing 120 completed flywheel assemblies per hour. No skilled labour is required.

With the sole exception of a fractional horsepower electric motor used to drive the feed rollers of the flywheel input station, at the rear on the right of the illustration, the machine is hydraulically operated. The entire set-up is self-contained, including the hydraulic pump, cooling system, motors, actuating valves and press cylinder. The only external requirements are air, water, and electric power supplies and the necessary control cables from a remotely sited relay cabinet. Flywheel-input and completed assembly-output stations are arranged "in-line" to fit into existing production lines. Gravity-fed flywheel blanks come directly from a previous operation to the motor-driven, roller-conveyor type, input station. Traverse through the machine is automatic and the completed assembly is ejected on to a roller conveyor which transfers it to the next operation. Ring gears may be loaded either in batches or by conveyor.

The outstanding feature of this novel machine is the combined heating coil and magazine. This unit consists of a special water-cooled, copper coil, operating directly from a 60 c/s tapped auto transformer, complete with glass-fibre insulation, wear-resistant metal liner and an automatic temperature-controlling, probe-type thermocouple. Above the coil is an automatic stripping device, resembling a stacked-type, gramophone-record changer, that strips off the bottom ring gear, moves it to the press area, and simultaneously supports the stack of gears in the magazine.

Basically, the work cycle consists of five operations :

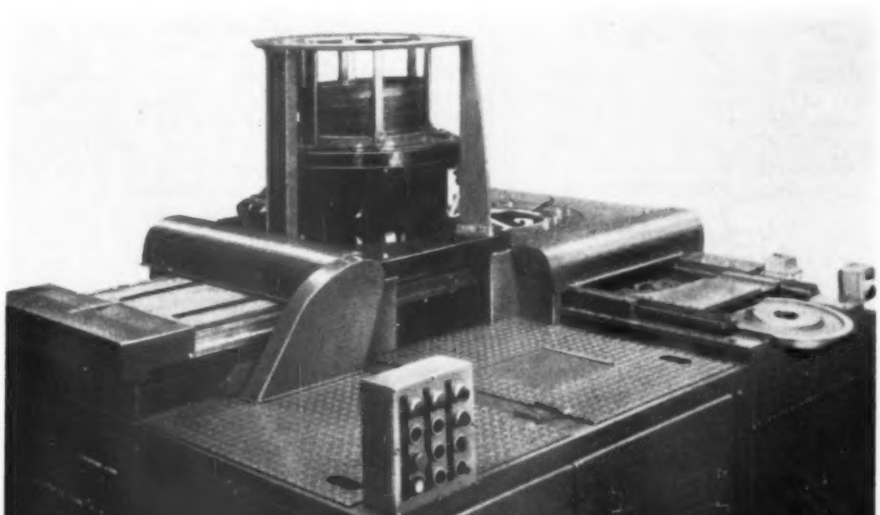
(1) Heating the rings
(2) Stripping a ring from the stack and moving it to the press area
(3) Indexing a flywheel blank under the ring gear
(4) Raising and pressing the flywheel into the ring gear against a bolster plate
(5) Air blast to chill and shrink.

A sixth operation is the ejection of the finished assembly, performed by the feed action in operation 3.

Mounted on the left at the front of the machine the pushbutton control station, in addition to the automatic-cycle start, is equipped with jog buttons to check the set-up of each operation, emergency stop, and indicating lights monitoring conditions of "heat on", "pump on", "standby" and "ready". Additional emergency stop pushbuttons are located at the input and output stations of the machine. An automatic temperature-control system prevents operation of the cycle until the rings have been brought up to the correct shrinking temperature, and also maintains correct temperature during the entire process. A retractable, probe-type thermocouple contacts only the bottom ring and signals a millivoltmeter indicator-controller mechanism to regulate the power loading of the heating coil, up or down, to maintain constant temperature conditions.

Other features include external grease fittings for all lubricated areas, making it unnecessary to remove side panels for periodic maintenance. Access doors, not panels, simplify the checking of the hydraulic pumping system. Another maintenance feature is the electrical wiring junction box on the left side of the machine. Every pushbutton, control switch, limit switch, hydraulic valve solenoid, and safety interlock is terminated in this box to reduce fault-finding time to a minimum. There is thus no need to dismantle separate junction and switch boxes to check electrical continuity or short-circuits; all can be traced from this common point on neatly coded terminal blocks. Power input is 18·5 kVA at 440 V, 60 c/s, single phase.

The Ther-Monic automatic machine for induction heating and shrink-fitting ring gears on flywheels. Designed for inclusion in a production line, it cycles at rates up to 120 assemblies per hour



The Clark Fan-Clutch

An Engine-Driven Unit Automatically Controlled by the Temperature of the Cooling Air Leaving the Radiator Matrix

As applied to the automobile, an internal combustion engine and its auxiliary equipment is required to be as light and compact as is economically practical. Thus, in order to be able to use a coolant radiator of reasonable dimensions it has been necessary, from the earliest times, to augment the flow of air through the radiator matrix by means of a fan. By driving the fan directly from the engine by a belt, such a radiator and fan cooling system was presumed to be self-adjusting to the fluctuating requirements of the engine.

If an engine were required to run under conditions of constant load and with a constant ratio between engine speed and driving axle speed, then the speed of the vehicle and the consequent induced draught through a forward-mounted radiator would provide the self-regulating, heat-dissipating system required to maintain a constant engine temperature at all speeds. However, by reason of variations in load and road gradient, and the installation of a multi-ratio gear unit between the engine and the driving axle, such conditions do not obtain in practice. There is, therefore, a case for the engine-driven fan; the efficiency of which depends upon engine speed rather than on the vehicle speed.

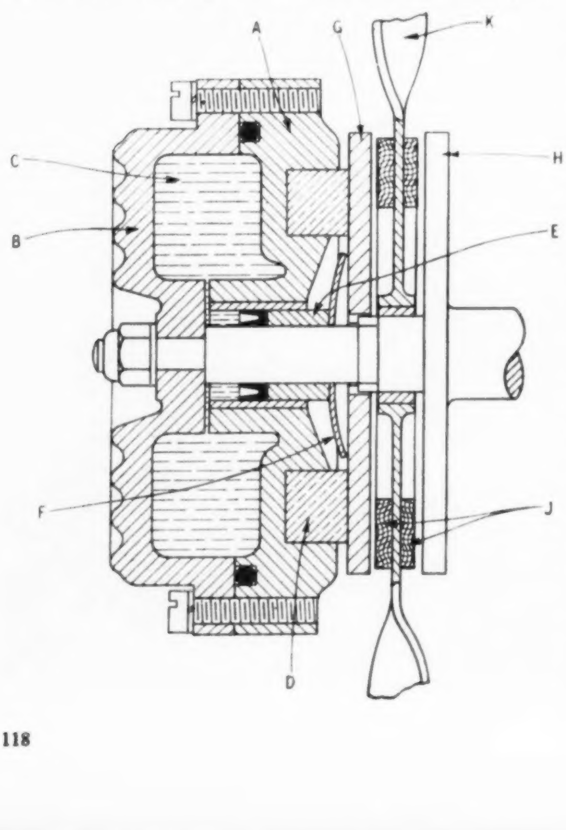
Since for so many years this system of radiator and engine-driven fan has been in general use throughout the world, it unquestionably provides a workable solution of the cooling problem. Nevertheless, the direct-coupled, engine-driven fan is not free from drawbacks. First, the fan absorbs a considerable amount of power, especially at the upper end of the engine speed range. Secondly, it may overcool the engine under conditions in which the naturally induced draught alone would be adequate to maintain the engine temperature constant. A seemingly obvious solution of this aspect of the problem is to provide means to disengage the fan from its drive in such circumstances.

The most obvious factor by which coupling or uncoupling of the fan is to be determined would seem to be the engine temperature, since it is this temperature that the cooling system is designed to maintain at an optimum value. For all practical purposes, engine temperature may be assumed to be the same as the coolant temperature. Accordingly, it should be arranged that the fan is coupled only when the coolant temperature has reached the predetermined value. Conversely, the fan should be uncoupled when the coolant temperature falls to below a second predetermined figure. In order to obtain operational stability, the uncoupling temperature should be at least 10 deg F lower than the coupling temperature. Later, it will be shown that there is advantage to be gained by monitoring the temperature of the cooling air after it has passed through the radiator matrix, rather than by monitoring the temperature of the coolant directly.

An automatic fan clutch, recently developed by A. N. Clark (Engineers) Limited, 95a Phipps Bridge Road, Merton, London, S.W.19, functions under the influence of air temperature on this system. When the unit is cold, the axially movable presser plate is held out of engagement by a permanent magnet. As the clutch is warmed by the air when the engine is running, an enclosed volume of oil expands and displaces a piston which compresses a spring and breaks free the presser plate from the hold of the magnet. Under the constraint of the spring the presser plate then clamps the fan against the clutch disc; the drive being taken up on friction material facings. When for any reason the air temperature falls and the unit cools, the oil contracts, pressure on the spring is relieved, and the presser plate is withdrawn by the magnet.

Sectioned arrangement of Clark automatic fan clutch. Shown in the "cold, disengaged" position

A clutch body; B cylinder; C actuating oil; D ring-type permanent magnet; E annular piston; F cruciform plate spring; G presser plate; H clutch disc; J friction facings K fan



The principle of operation can best be explained by relating the action as the clutch moves from the "cold, disengaged" position to the "hot, engaged" position, and by reference to the sectioned arrangement drawing in which the unit is shown disengaged. In the closed cylinder B of the device is contained a relatively large volume of oil C from which all air has been excluded. The coefficient of volumetric expansion of the oil is approximately 0·00044/deg F, and upon the temperature of the cylinder and the oil being raised the expansion results in pressure being exerted on the small annular piston E. As the piston moves outwardly under this pressure it compresses the bowed, cruciform, plate spring F but does not, at first, move the presser plate G which is held by permanent magnet D in the clutch body A. The fan remains freely rotatable on its bearings. Continued temperature rise of the oil results in further movement of the piston until the

spring is bottomed on the presser plate and thereafter the presser plate is lifted from the magnet.

Immediately an air gap occurs between the magnet and the plate, the spring is released and endeavours to revert to its original contour. The presser plate is moved outwardly under spring constraint to clutch the hub of the fan, faced on each side with friction material J, against the clutch disc H and to take up the drive. The clutch unit will remain in the engaged position until the oil contracts on cooling and the piston is retracted by atmospheric pressure. Then, when the spring constraint is relieved, the magnet will re-engage the presser plate and hold it in the free clutch position. A characteristic feature of a permanent magnet is the rapid reduction of magnetic attraction which occurs when a small air gap interrupts the magnetic flux path. This property, illustrated in the accompanying graph, is employed in the fan unit to obtain a positive, snap-type operation of the clutch.

In the design of the unit various factors influencing the oil pressure within the cylinder must be given consideration.

(1) Volume of oil subjected to temperature changes
(2) Range of temperature variation
(3) Coefficient of expansion of the oil used
(4) Coefficient of expansion of cylinder material
(5) Structural rigidity of cylinder.

Similarly, a number of factors affect the idling speed of the fan when disengaged.

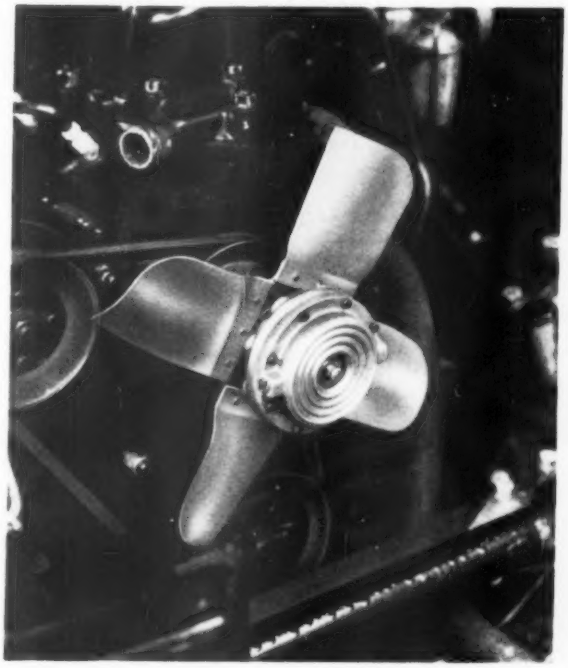
(1) Friction of fan hub bearing
(2) Air flow through radiator when vehicle is in motion causes fan to "windmill"
(3) Fan is thrust rearward against the clutch disc by air pressure due to forward motion of vehicle
(4) Slight forward thrust arising from factor 1 is opposed to that of factor 3.

A fan clutch should have a two-fold function. First, it should ensure that the fan is disconnected from its drive when the engine is started from cold and should engage it only when the engine has attained its predetermined working temperature. Secondly, when the engine is running at the appropriate temperature, if the naturally induced air flow through the radiator—by reason of its volume, velocity, temperature, or any combination of these factors—becomes sufficient to maintain engine temperature at a steady value, then the fan should again be disconnected.

To achieve these objectives, the Clark unit monitors the temperature of the cooling air after it has passed through the matrix of the radiator. For a given coolant temperature and heat input, the temperature of the fan clutch will be lower when the air passes through the matrix at high velocity than it would be at low velocity. This follows, although for any specific interval of time the heat extracted by the air will be approximately the same, because when the velocity is higher the heat will be distributed over a greater mass of air. Thus it will tend to lower the temperature of the clutch to a value below that which might be expected from consideration of radiator temperature alone. As a consequence, the cut-out of the fan will be relatively advanced and will anticipate requirements when vehicle speed increases to the point where the heat-extracting capacity of the air induced by the forward motion makes unnecessary additional cooling by the fan.

Should the temperature of the air fall for any reason, the clutch unit will immediately detect it and, within the margins of its capability, commence appropriate corrective action. In systems monitoring coolant temperature a change must occur in the coolant temperature before the cooling air flow can be adjusted and, consequently, engine temperature will fluctuate. The Clark unit monitors temperature changes of cooling air flow that would affect coolant temperatures and in turn engine temperature, if allowed to continue with the flow unadjusted. However, due to the thermal inertia of engine block, coolant, and lubricating oil, no measurable temperature change need occur to them. Clearly, therefore, the thermal inertia will assist the Clark unit to maintain a constant-temperature engine condition. The same thermal inertia necessarily hinders the timely action of any system which monitors coolant temperature.

The thermostatic valve included in most coolant systems enables a rapid block warm up to be obtained by by-passing the radiator and causing the coolant to circulate within the engine until it has attained a reasonable operating temperature, usually preset in the region of 165 deg F. This is obviously highly desirable in any circumstance. The fan clutch in no way obviates the need for the thermostatic valve, nor does a thermostatic valve make a fan clutch unnecessary. Rather the two components are complementary.



Clark automatic clutch fitted on Austin-Healey Sprite engine. The actuation cylinder is approximately 3 in diameter and there are no controls or external connections

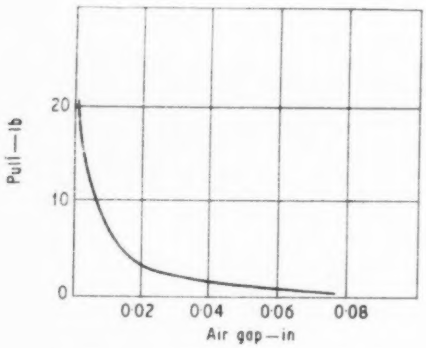
Four major advantages are claimed for a clutched fan over a directly coupled fan

(1) Reduced engine warm-up time
(2) Increased power available for useful work when forward speed is sufficient for engine cooling
(3) Elimination of fan noise under cruising conditions
(4) Reduced risk of running engine in an overcooled condition
(5) A modest reduction in the rate of fuel consumption.

The desirability of reducing the warm-up period, with its damaging effects on the engine and its unpleasant driving characteristics, needs no elaboration here. It may be added, however, that in the case of the engine of the family car which usually gets thoroughly cold between running periods, this aspect is of particular importance.

The curves showing the warm-up period with and without a fan clutch were obtained on an Austin-Healey Sprite running under normal road conditions. They were taken on consecutive days, travelling over the same route; the wind

speed and direction were adjudged to be approximately similar on both days. In any actual road tests of this kind, external factors such as density of traffic, and the hazards of road signals, can make quite appreciable differences to the results obtained. However, in this case the manifest improvement obtained with the fan clutch in action is sufficient to discount the influence of such variables on the results. Furthermore, as these are the actual conditions under which the unit will have to operate in service, the unexpected results that can be obtained in certain circumstances of traffic give them a very real operational value, even if they are not strictly comparable.



Typical curve of pull exerted by permanent magnet

As regards the second advantage, it is probably advisable to consider a specific example. A commercial vehicle engine under conditions of maximum power develops, say, 100 h.p. At the engine speed at which this power can be produced the power absorbed by the fan may be 8 h.p. or more. However, there will exist many circumstances when the vehicle, although cruising at high speed due to favourable conditions of load and gradient, will require from the engine, say, only 50 h.p. The power being absorbed by the fan will still be 8 h.p. due to the high engine speed. It is clear that the excess heat with which the fan is capable of dealing does not exist under such cruising conditions, and that which does obtain could almost certainly be dealt with by the naturally induced air flow through the radiator. The power saving in such a case would be about 14 per cent, with a consequential reduction in fuel consumption.

The third advantage claimed is self explanatory. In magnitude of effect it will vary considerably on different vehicles. Possibly it is of prime importance only in the case of the large private motor car.

Listed as the fourth advantage, the reduced risk of an overcooled engine will apply normally only in winter. Overcooling, frequently unsuspected, is not uncommon and is revealed by a tendency for the engine to stall on tick-over, even after a very considerable mileage has been covered. Equally undesirable is the considerable increase in fuel consumption which occurs simultaneously.

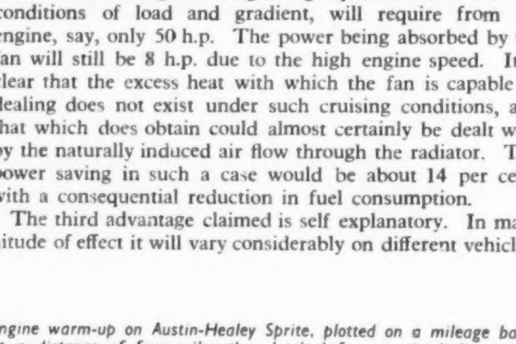
Lastly, the decrease in the rate of fuel consumption is rather difficult to assess since it can be influenced by many variables. If the reduced power requirement with the fan disengaged is utilized to improve the performance and raise the vehicle's average speed, any saving is likely to be absorbed. Experience has shown that on fitting a Clark clutch a reduction of from 3 to 5 per cent on previously ascertained consumption figures may be expected.

It would seem, therefore, that the Clark clutch offers advantages not possessed by devices which either monitor the coolant temperature or are arranged to slip at a predetermined engine speed. The shortcomings of the coolant-controlled clutch have already been stated. In the case of the slipping device no assistance is given during the warm-up period and the slip speed would appear to be determined to meet specific, or at best, average conditions of load, gear ratio and forward speed. Obviously, it would not be of assistance in the case of a heavily loaded vehicle climbing a long steep grade in a low gear—in fact, it could be a handicap. Not a few British vehicles, with a conventional direct-coupled fan, have been found to be undercooled under such conditions in the Alps.

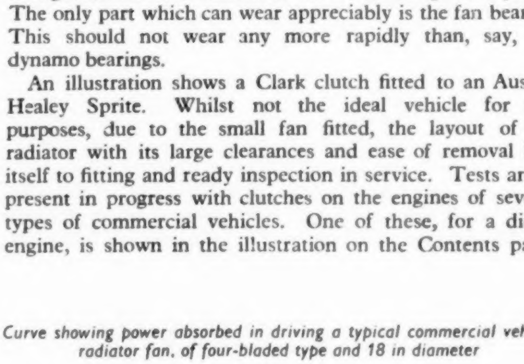
The price to be paid for the advantages obtained by the fitting of a fan clutch is virtually limited to the first cost, since maintenance required has been found to be negligible. Leakage of oil, although a source of trouble at the beginning of development, does not now present any special difficulties. The friction linings have shown themselves to wear so little as to be immeasurable once the "bedding in" process has been completed. This is probably because the lining material is loaded well below its designed capacity. The only part which can wear appreciably is the fan bearing. This should not wear any more rapidly than, say, the dynamo bearings.

An illustration shows a Clark clutch fitted to an Austin-Healey Sprite. Whilst not the ideal vehicle for test purposes, due to the small fan fitted, the layout of the radiator with its large clearances and ease of removal lent itself to fitting and ready inspection in service. Tests are at present in progress with clutches on the engines of several types of commercial vehicles. One of these, for a diesel engine, is shown in the illustration on the Contents page.

Engine warm-up on Austin-Healey Sprite, plotted on a mileage base. At a distance of four miles the clutched fan remained disengaged



Curve showing power absorbed in driving a typical commercial vehicle radiator fan, of four-bladed type and 18 in diameter



Centreless Grinding

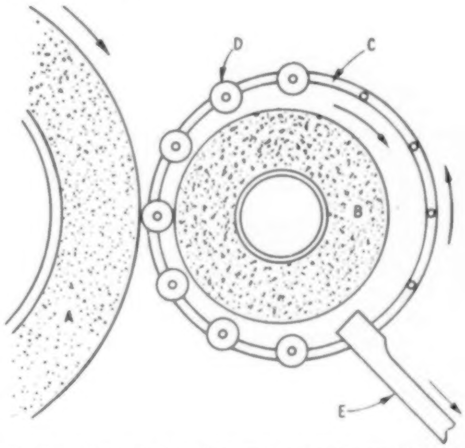
A New, Easy Loading, Automatically Ejecting, Work Carrier for Small Wheels and Other Axially Bored, Cylindrical Components

OF late years manufacturers of centreless grinding machines have proved themselves to be particularly resourceful in devising and developing unusual feeding and work-handling methods. These innovations have enabled the capacity of centreless grinders to be extended to handle work of a variety such as would have been barely credible at an earlier stage of their development.

A recent example of somewhat unusual work and an interesting method of handling is the grinding of the small, numbered wheels such as are now required in ever-increasing quantities for industrial counters, digital recorders, ratchet counters, revolution counters, and similar instruments. These wheels, about 15 mm diameter, are moulded in a black, plastics material and have the figures 0 to 9 deeply impressed around the periphery. For ease of observation the impressions are filled in with white paint. The entire circumferential surface of the wheel is first sprayed with paint and the object of the grinding operation is to remove this paint from the surface and simultaneously to clean up the diameter dimensionally.

A novel method of handling this work has been evolved by the firm of Arthur Scrivener Ltd., of Tyburn Road, Birmingham 24. The basic machine employed is the smallest model of the range of centreless grinders produced by the firm, the Wickman-Scrivener No. 0. In this instance, it is equipped with a 12 in diameter, 2 in wide, grinding wheel, running at 1,800 rev/min, and a control wheel 7 in diameter and $1\frac{1}{2}$ in wide. The carrier feed comprises a ring having on each side a series of pins upon which the workpieces are mounted.

As shown schematically in the line diagram, the carrier ring encircles the control wheel but, relatively, is mounted eccentrically. Loading of the workpieces is effected manually by the operator at the sector of the ring remote from the grinding wheel where, due to its eccentric arrangement, it is freely accessible. Driven by an independent motor, the ring carries the workpieces round to the grinding position approximately level with the wheel axis. There the workpieces establish contact also with the control wheel



A grinding wheel; B control wheel; C carrier ring; D workpiece; E discharge chute

Diagram illustrating the principle of centreless grinding small wheels by mounting on a carrier ring

which supports them whilst they are being ground. The finished workpieces are retained on the carrier ring until they reach a point approximately one-third of a revolution from the grinding position. They are then displaced from the ring and ejected into a forked discharge chute by means of a blast of compressed air.

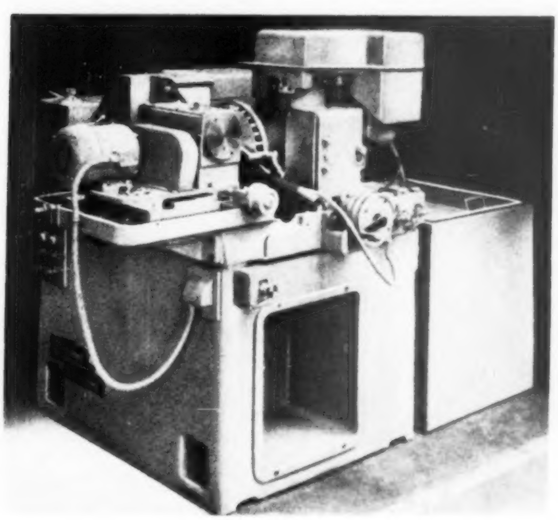
Claimed advantages for this system, as compared with other methods available for work of this type are that it ensures:

(1) Concentricity of the periphery with the axial bore
(2) Freedom from run-out of the wheel on its bore-axis
(3) Close dimensional accuracy.

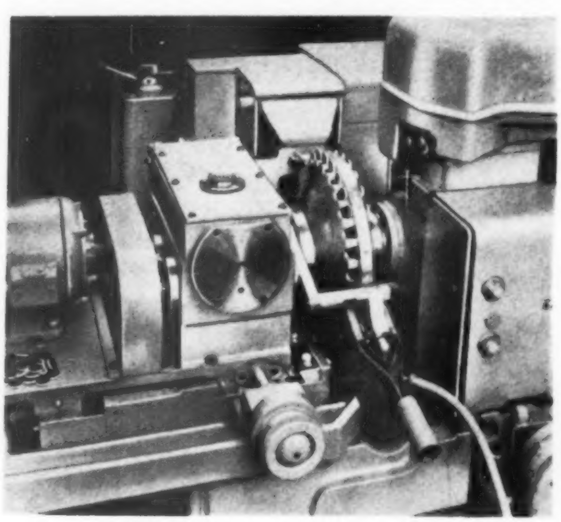
All these aspects are of prime importance in the class of work for which the set-up is intended.

Production of typical work is approximately 4,000 pieces per hour, with a stock removal that may be as much as 0·45 mm (0·018 in).

Wickman-Scrivener, Model O, centreless grinding machine



View of carrier ring, showing loading sector and air-blast ejection station



SECTIONIZED TRANSFER MACHINE

Six-cylinder and Twelve-cylinder Blocks for U.S. Truck Engines Machined on a Single Cross "Transfer-Matic" Line

A SPECIALLY designed, fully automatic transfer line for a single component can offer the greatest saving in the unit cost of production providing the volume requirement is sufficient to keep it in full operation. If the line stands idle for any considerable portion of its working life, the heavy capital investment in tools and equipment, the valuable factory space occupied, and necessary maintenance, will rob it of its potential advantage. Much has been done in the virtual standardization of machine heads, pedestals, and transfer and indexing elements, to lower the cost and reduce the time required to design a line, on the so-called "block" principle. Only the tooling remains specialized for the specific component to be produced.

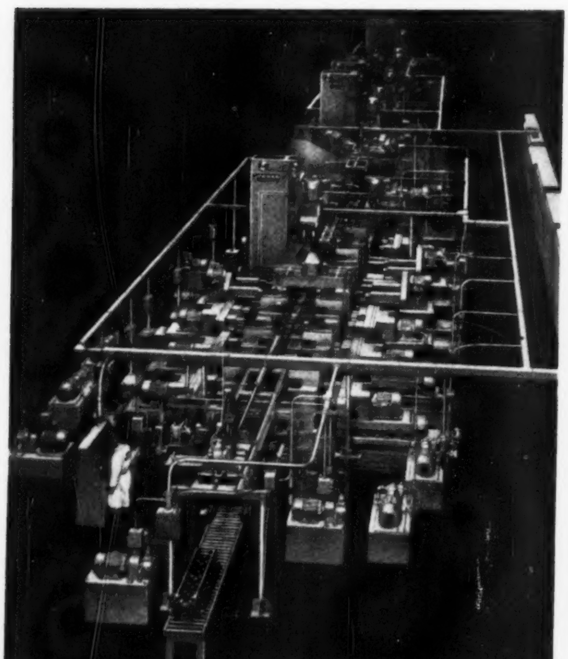
In spite of this progress, and the collaboration of product manufacturer and machine builder in planning a line, intensive study is required before a transfer line can be specified for a medium-volume, as distinct from a very high-volume production requirement. Much ingenuity has been displayed in the layout of lines to handle more than one component, to be adaptable to component design changes, or to obtain flexibility in order to meet currently fluctuating and possible future volume requirements.

Several interesting layouts have already been described in these columns. Brief reference may be made to the method used to machine the cylinder blocks and cylinder heads of diesel engines of two different sizes*. Separate lines were built for blocks and heads, and each was equipped with duplicate tooling. To meet varying requirements, each line was operated for a period—commonly two or three weeks—on a component of one size, then the tooling was changed at a week-end, and a run made on the other-sized component. In another instance, four different models of a transmission housing were to be machined†. They were required in widely differing quantities and one model in particularly high volume. Two lines were built; a short, single-purpose line exclusively for the high volume model and a long line capable of machining the three other models and also the high volume model. This long line was divided into three sections, and one of these into three subsections with the addition of a switch line. The four different models are handled respectively by passing through certain sections, and switching in some instances.

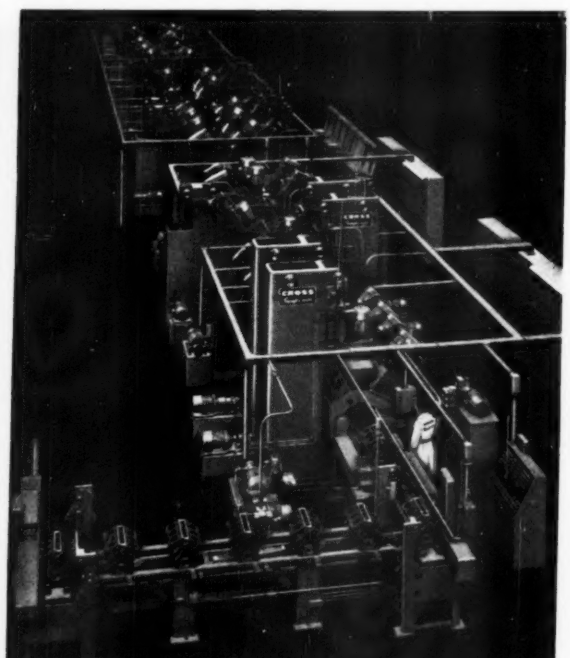
Recently a line has been installed by a U.S. truck manufacturer to machine three different versions of a six-cylinder vee-type engine block and also a twelve-cylinder block. This is accomplished on a single line, termed a Sectionized Transfer-Matic line, designed and built by the Cross Company, Detroit, Michigan. The cost of this line is claimed to be only slightly more than that required for a single-purpose line to machine either one of the blocks. Operations include boring, drilling, reaming, tapping, chamfering and spot-facing. Of 579 operations performed on the six-cylinder block and the 901 operations on the twelve-cylinder block, 454 are common to both. Non-common operations are carried out with additional stand-by machine heads and spindles at suitable locations.

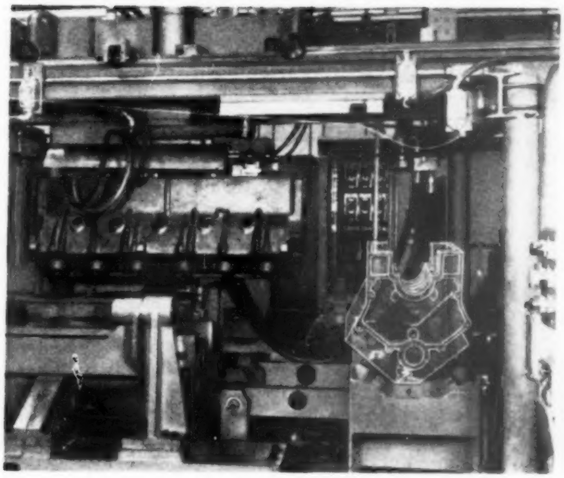
**Automobile Engineer, January 1956.*
†Automobile Engineer, August, 1959.

Twelve-cylinder block entering first two sections of the line that completes all machining operations on both ends, sump face, underbanks, and sides of both six-cylinder and twelve-cylinder blocks



Six-cylinder blocks come off the accumulating conveyor and enter the final sections of the line. Machining of top and bank faces of all blocks is performed in these sections





A block leaves the first section in the attitude sketched at the right. From this position, it can be removed for banking, or turned 90 deg for entry into the second section

One of the nine probe stations where blocks are checked to ensure that holes are correctly machined. A defective part is manually removed from the line and taken to a salvage area

Six-cylinder blocks are required in much higher quantities than twelve-cylinder blocks, and the new line well illustrates the substantial economy and improved processing that can be effected by integrating the design of the product with the design of the production equipment. Had the twelve-cylinder block been designed without due consideration of the more widely used six-cylinder block, automatic production of it could not, in all likelihood, have been justified. In the layout of the machining line the six-cylinder block was regarded as the basic unit and the twelve-cylinder block was designed as six two-cylinder units cast integrally.

Among features common to both blocks are identical cross sections, hole patterns at front and rear faces, and hole patterns at the joint faces for the cylinder heads. Machine heads are arranged to accommodate the twelve-cylinder block, and a novel two-stop transfer mechanism has enabled the number of spindles required to machine it to be reduced by approximately 50 per cent. Time added to the cycle time by this double stroking is not prohibitive.

The total length of the line is 450 ft, arranged with machining sections on both sides of an accumulating conveyor. This conveyor is connected to the machining sections and provides the means by which a steady output is maintained during changeover operations from one engine block to another. Machining lines are divided into sections, with space for the banking of work at the end of each section. Withdrawal of parts from the line for banking is not automatic, being manually effected with the aid of overhead hoists. By the provision of banks of parts and the use of the accumulating conveyor, it is possible for one section of the line to be operating on six-cylinder blocks, another on twelve-cylinder blocks, while others are changing over.

Construction of the line on the "block" principle ensures flexibility for modification to meet possible future component design changes, or even for processing entirely different parts. In the 82 stations of the line are 25 idle stations. The reasons for their inclusion are to prevent heat build-up in the workpieces and the fixtures, to improve access for servicing current working stations, and to provide space to add machine heads for additional operations.

Six-cylinder blocks move through the line in the conventional manner, but twelve-cylinder blocks are traversed on a somewhat more complicated course. In order to accommodate offset identical hole patterns and repeated hole patterns, the twelve-cylinder blocks are at some stations shuttled to one side, at other stations the drill heads and bushing plates are shuttled, and at yet other stations the block is indexed twice under each multiple-spindle head.

To obviate the possibility of damage to machined locating faces, the relatively heavy blocks are not slid from station to station. Instead, lift-and-carry transfer mechanisms are used throughout the machining sections.

Long oil-gallery holes are drilled progressively in one of the line sections. These holes extend the full length of the block and are drilled halfway from each end. To complete the holes, five passes are sufficient for six-cylinder blocks, but eight passes are required for the twelve-cylinder unit. Both cemented-carbide and HSS tools are used on the line. Carbide tools are employed for boring at speeds of from 200 ft/min to 300 ft/min, and for reaming at 100 ft/min. For drilling and tapping, HSS tools are used at speeds ranging from 40 ft/min to 70 ft/min.

Many in-process inspections are performed automatically; 170 and 231 inspections on six-cylinder and twelve-cylinder blocks respectively. Should a defective part or a broken tool be detected the machine is stopped automatically. The faulty block is removed manually and transferred to a salvage area for examination and possible reclamation.

Each of the four main sections of the line can be changed over from production of one block to production of the other in an average of four man-hours. This, it is claimed, is only approximately 5 per cent of what would be required for a similar changeover with conventional equipment. To simplify setting-up, spindles and tools are given a code marking. Two rings machined on a tool indicate that it is used solely on twelve-cylinder blocks, and a single ring that the tool is only for six-cylinder blocks. Absence of marking on a tool implies that it is common to both workpieces. This coding system is applied also at the 17 machine control units, in order that a rapid visual check can be made to ascertain that all the correct tools have been used in a set-up. "Toolometers" at the machine control units keep a record of production cycles and indicate when a tool should be changed. Two sets of pre-set tools are stored at each machine control unit.

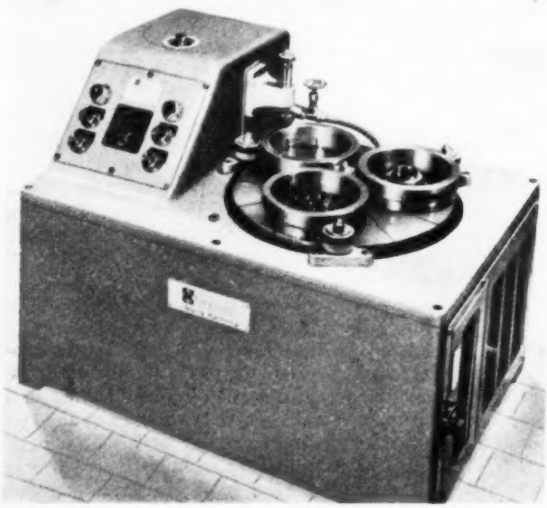
In production, the line can machine any one of the three versions of the six-cylinder unit in 54 sec, or the twelve-cylinder block in 103 sec. Operated at 100 per cent efficiency, therefore, the capacity of the line would be 66 six-cylinder or 35 twelve-cylinder blocks per hour.

New Plant and Tools

Recent Developments in Production Equipment

FOR lapping the surfaces of small components to high standards of flatness and surface finish, a new and relatively low-cost machine has been introduced by Flexibox Ltd., Nash Road, Trafford Park, Manchester, 17. Its maximum overall dimensions of 32 in × 22 in × 20 in enable the machine to be bench mounted, thus minimizing space requirements. Furthermore, anti-vibration pads on the base obviate the need for bolting down.

Designated the Flexibox lapping machine, Mark 15A, the machine is completely self-contained and can be used for the precision lapping of most constructional materials—plastics, ceramics, light alloys, and ferrous metals. Surfaces can be processed smooth and plane, to optical limits if required, both rapidly and accurately. Typical applications include deburring, surface finishing and lapping of small components requiring a high degree of surface finish.



Flexibox Mark 15A lapping machine
(Flexibox Ltd.)

For such a relatively small machine the capacity is high. The 15 in diameter lapping plate is equipped with three wear rings and it is possible to process 66 components of 1 in diameter simultaneously. Larger components can be handled, up to a maximum of 5½ in diameter.

An automatic flatness-control device maintains the lapping plate truly flat at all times and, consequently, the machine can be operated by unskilled labour. If necessary, more than one machine can be tended by a single operator, since the machine is also fitted with a timing device which can be preset for any desired period. In normal usage the range is up to 60 minutes, at the end of which the drive motor is automatically shut off. Coloured warning lights give a clear visual indication of whether the machine is in operation or shut down, so that constant supervision during running is unnecessary.

Surface grinding machine

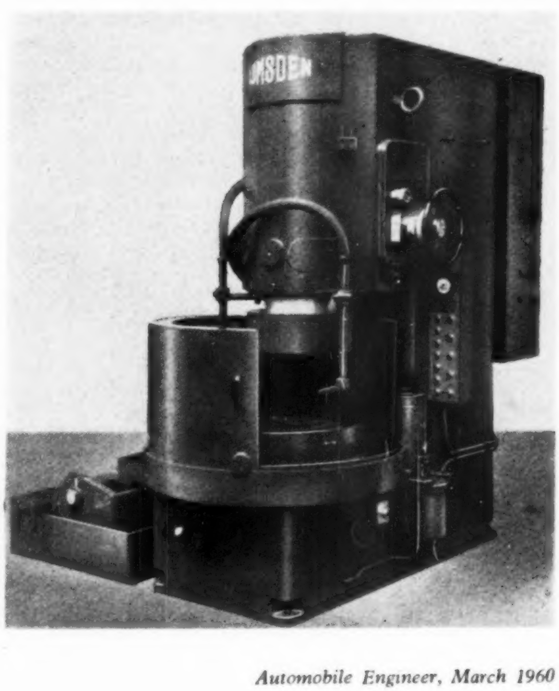
The latest addition to the range of surface grinders produced by the Lumsden Machine Co. Ltd., of Gateshead-on-Tyne, the Model 90 ML incorporates a new automatic feed control to the wheel spindle ram. With this mechanism it is now possible to preset accurately the amount of stock to be removed. For example, if 0·050 in is to be removed and the estimated or ascertained ratio of stock removal to wheel wear is 10:1, the trip dial is set to 50+5=55. The feed rate adjuster is set to any one of ten feeds available, according to surface area and material to be ground. The trip dial turns as the wheel descends so that it shows the amount the wheel still has to feed, and feed stops when the trip dial registers zero. A second dial is provided for setting and adjusting the trip mechanism; this dial is graduated in very widely spaced increments of 0·001 in.

Another development on this machine is an important new safety device which ensures that should the current to the magnetic table fail, a relay starts the elevating motor of the wheel spindle ram in the upward direction and all other motors stop. Thus the wheel is clear of the work before the residual magnetism has decreased sufficiently to allow the work to be thrown off the table as it slows to a stop.

Other electrical interlocks are provided to ensure safety of operation. For instance, the feed handwheel must be pulled outwards before the feed motor can be started. This ensures that there is no danger of a blow from the spokes of the handwheel and that the "Down" button is inoperative, should this inadvertently be pressed instead of the "Feed Start" button. Another interlock ensures that the magnetic table must be energized before the spindle motor can be started.

Sole selling agents for this and other Lumsden surface grinding machines are Alfred Herbert Ltd., Coventry.

Lumsden 90 ML surface grinder with automatic control of ram feed
(Alfred Herbert Ltd.)



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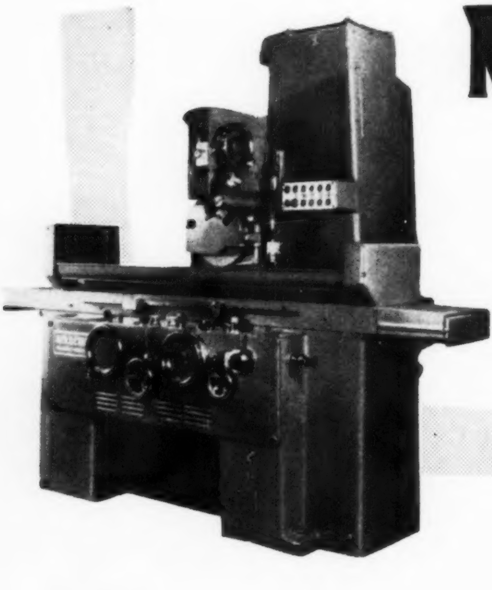

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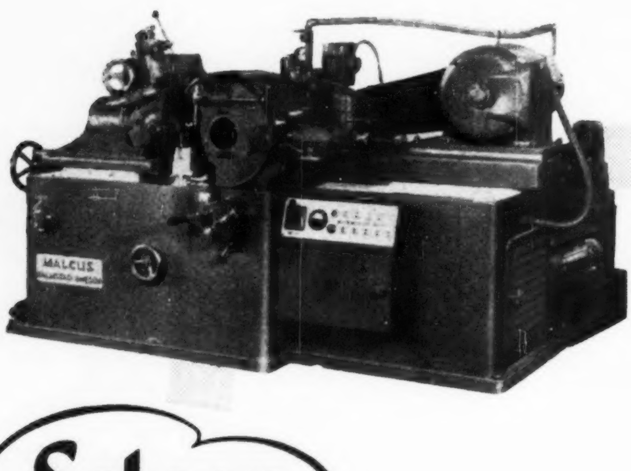

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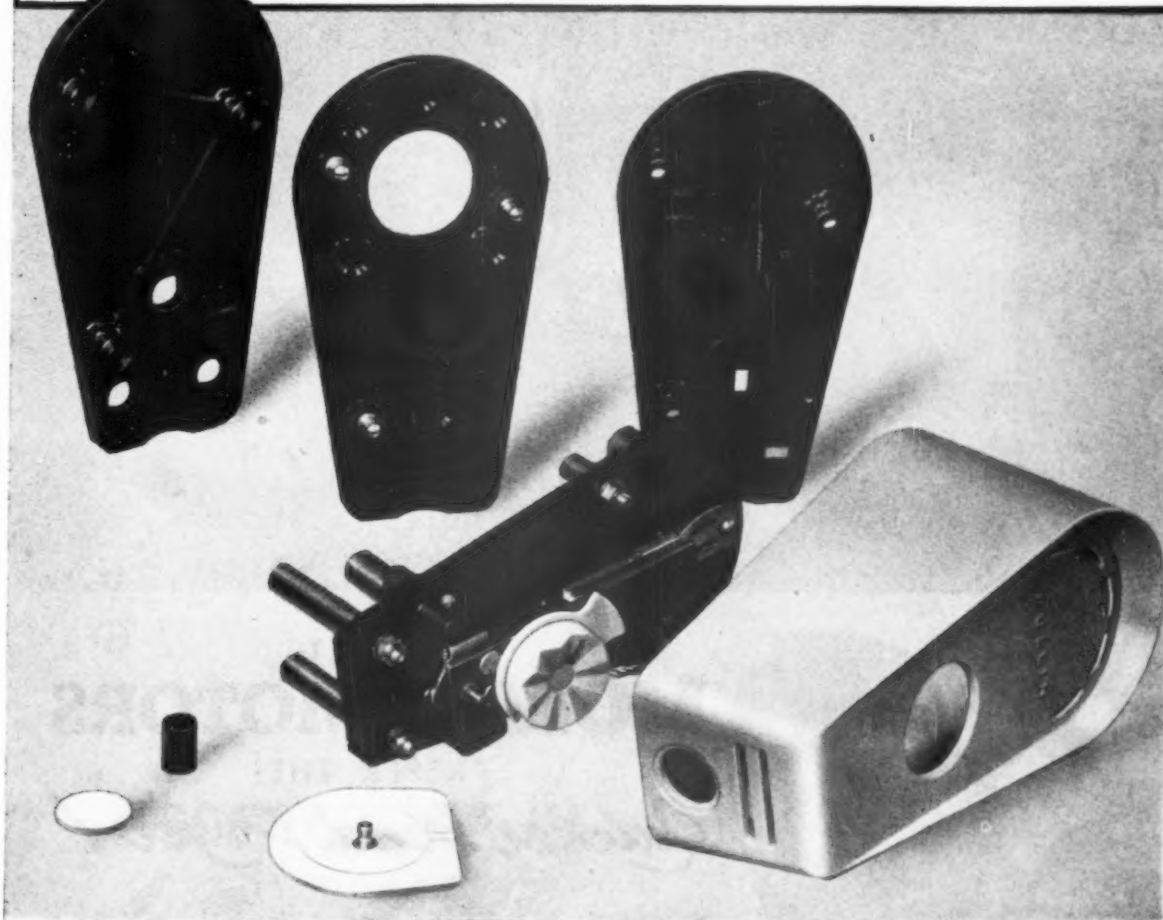

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Metropolitan Plastics Limited

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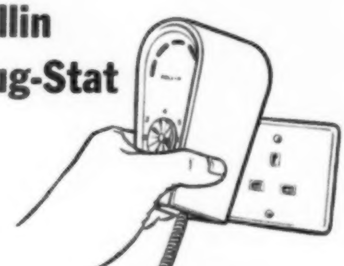

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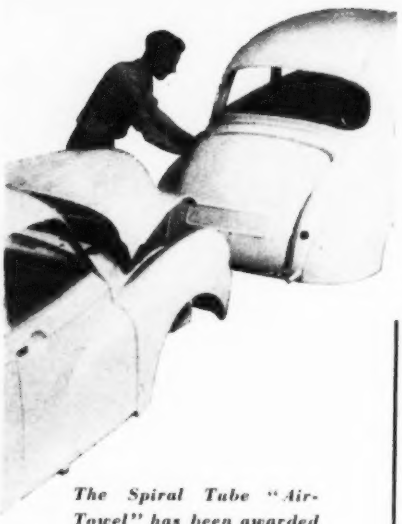

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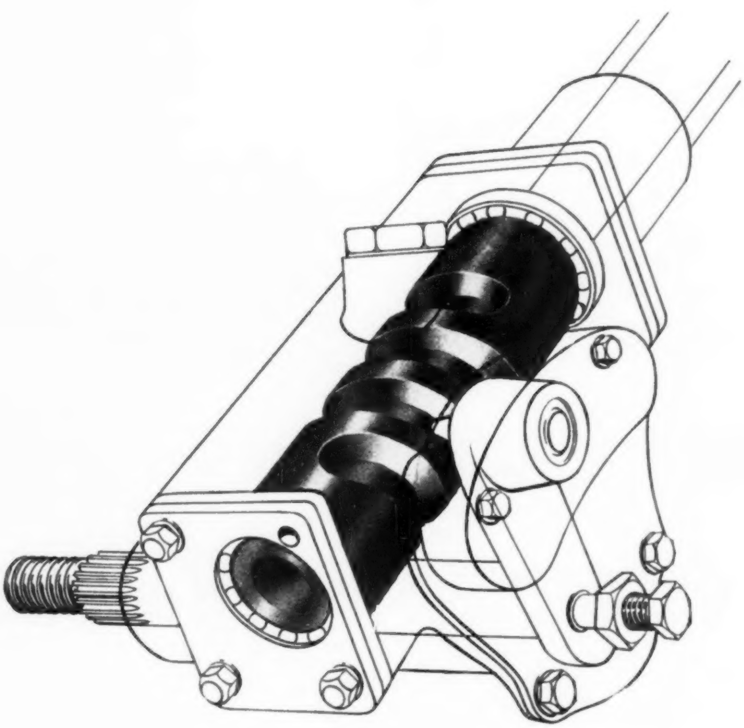

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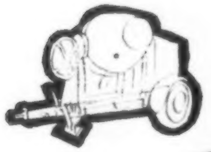
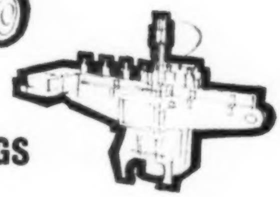

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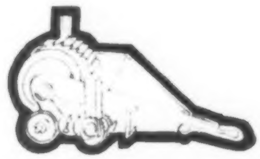


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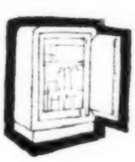

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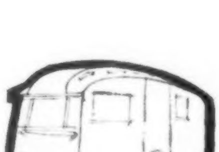


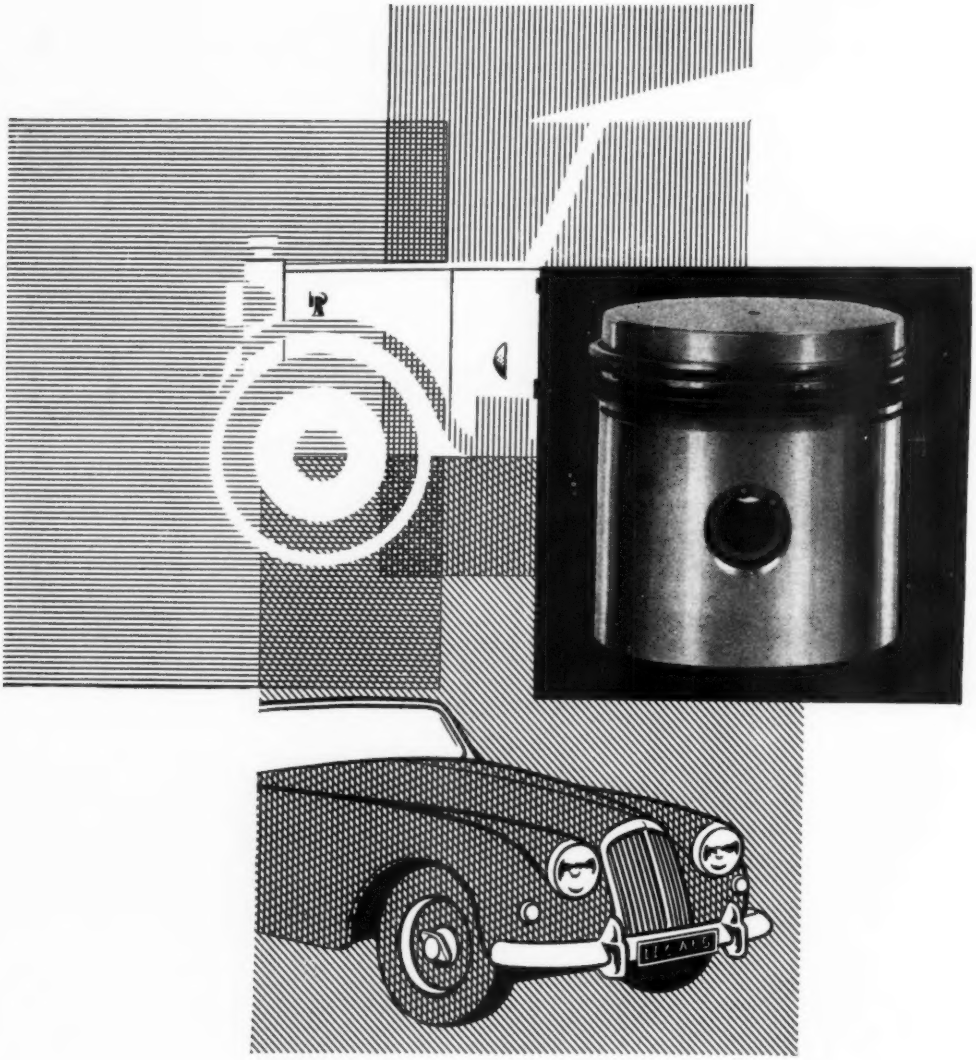

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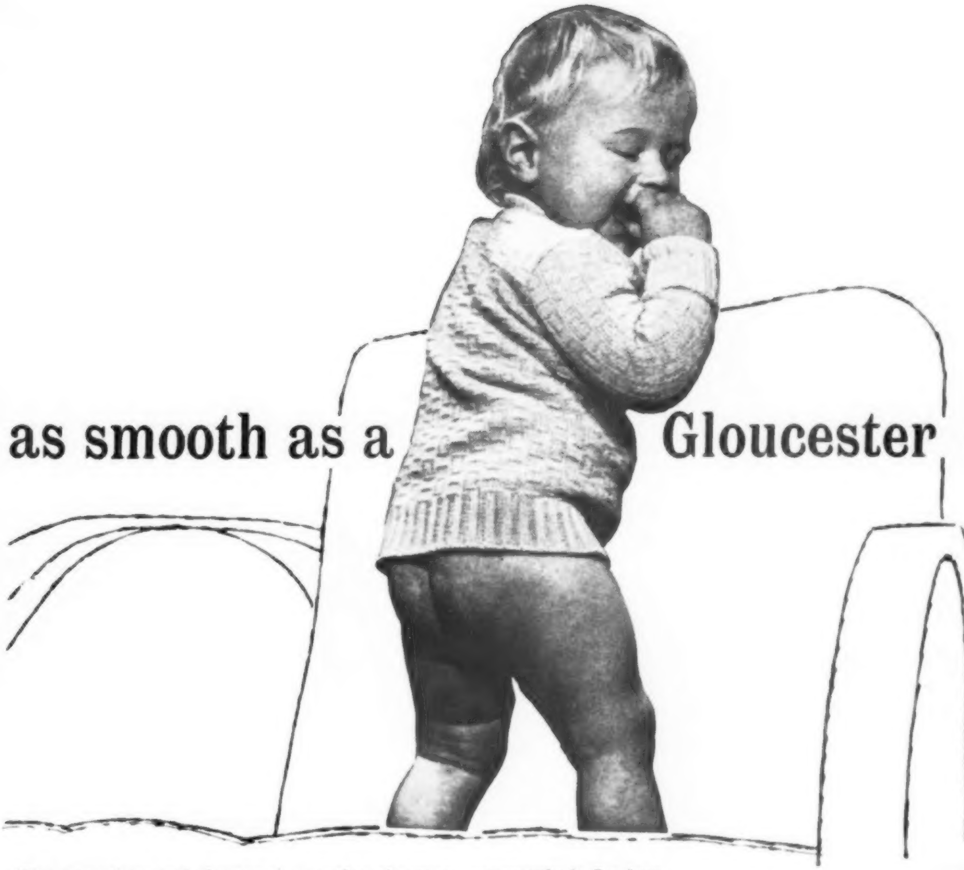

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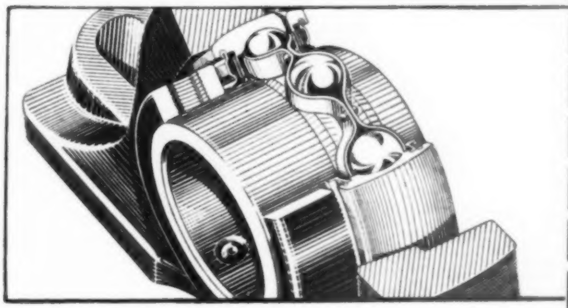

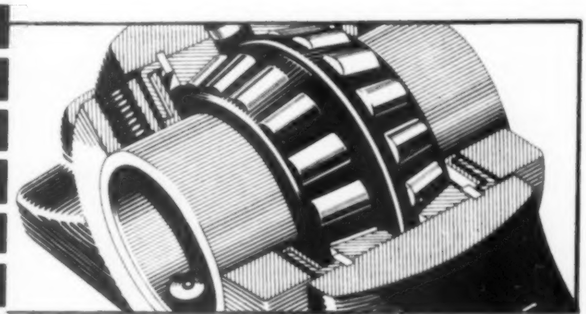

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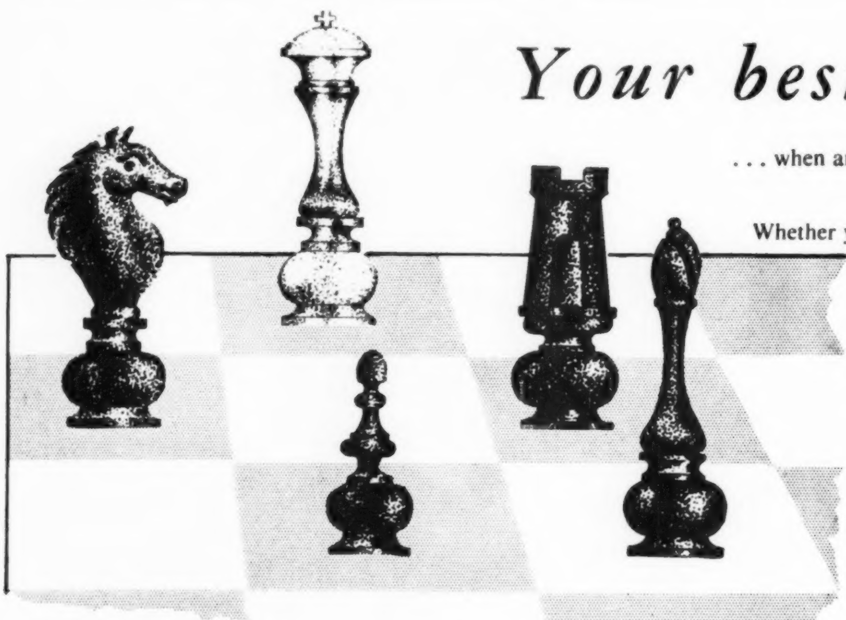

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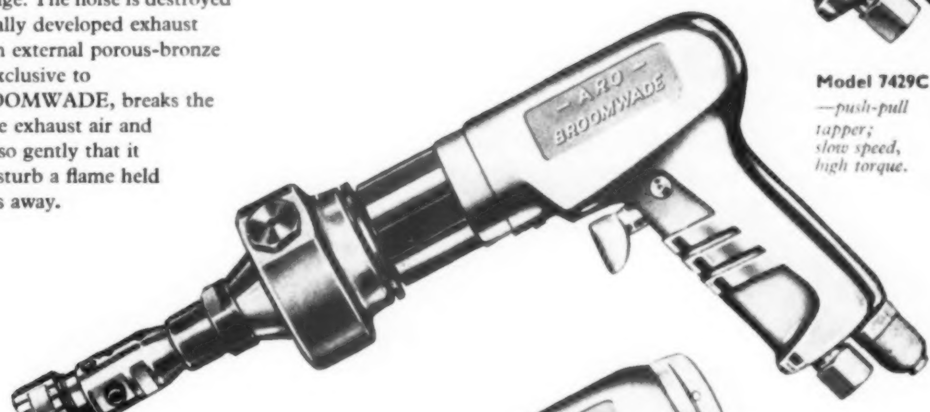

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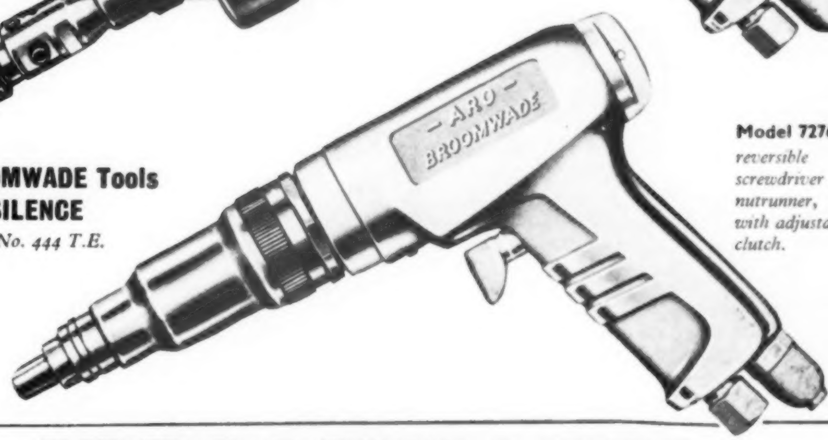

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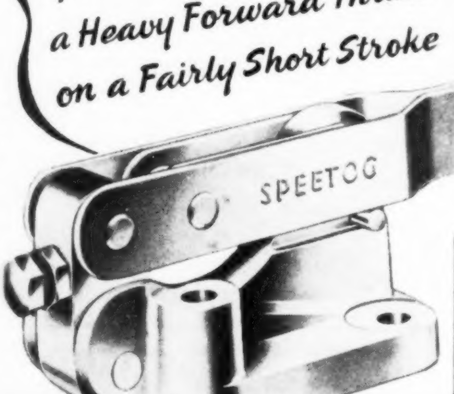

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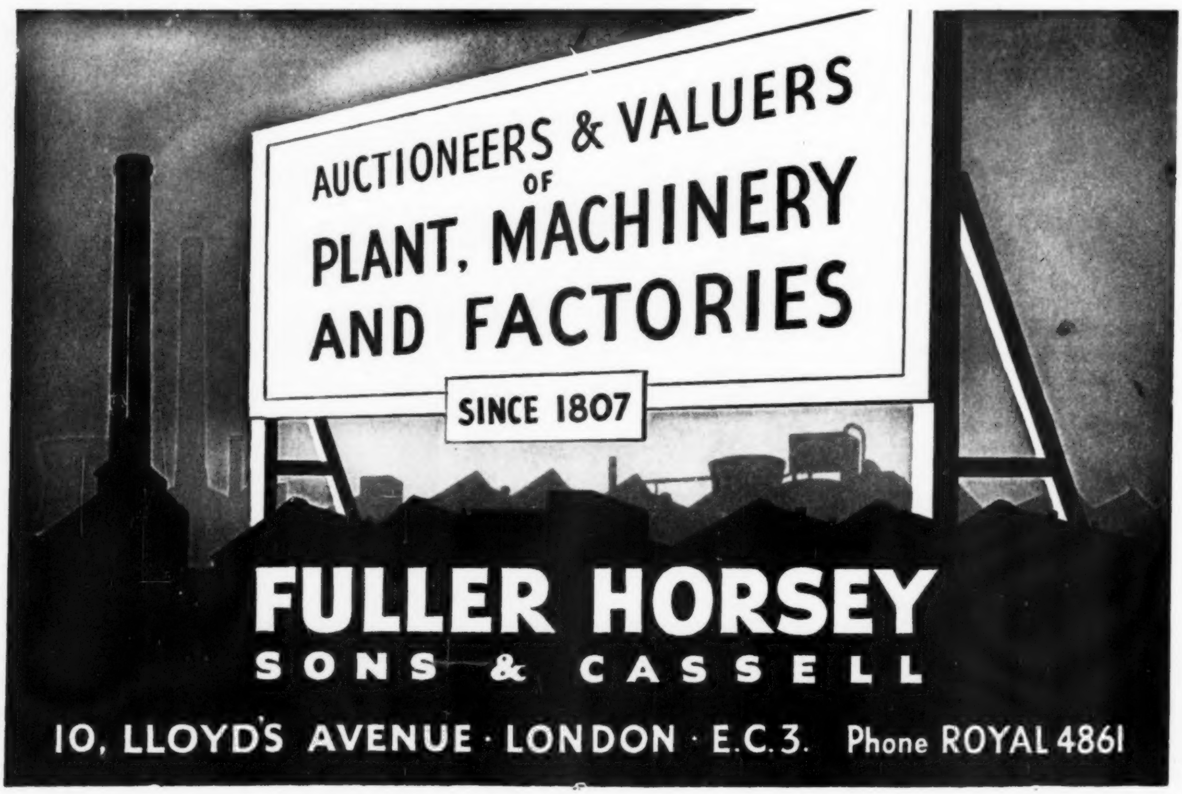

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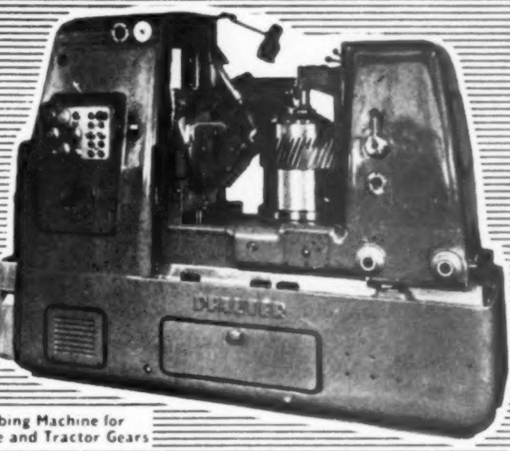
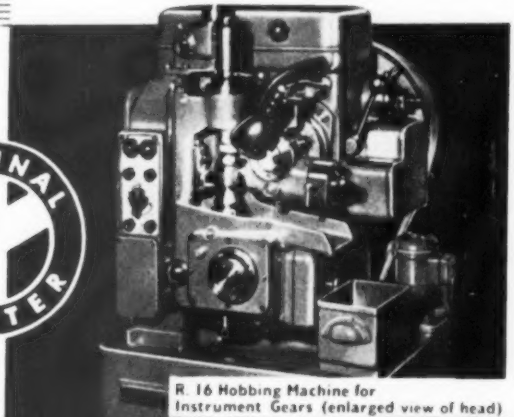

P. 400 Hobbing Machine for Automobile and Tractor Gears

There's one to meet *Your* needs...


R. 16 Hobbing Machine for Instrument Gears (enlarged view of head)

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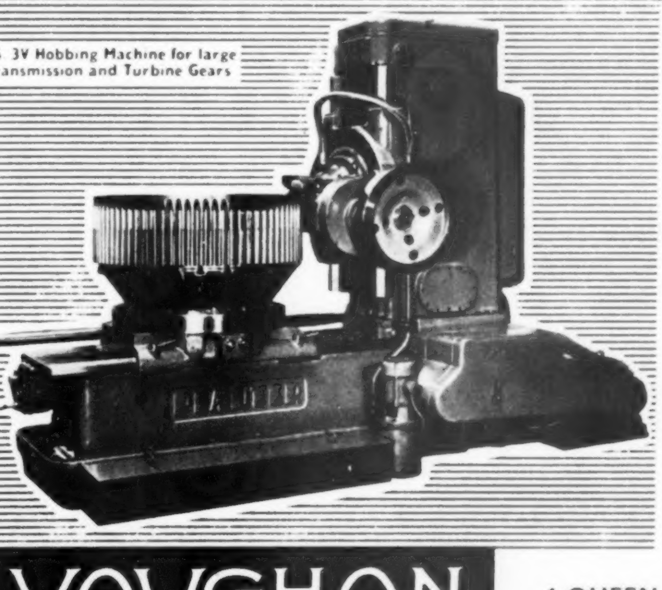
RS. 3V Hobbing Machine for large Transmission and Turbine Gears

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Model	Max. Gear dia. in.	Max. Gear width in.	Max. D.P.
R16	3	$2\frac{3}{4}$	26
RS00	10/6	7	17/10
P250	10/8	$6\frac{1}{2}$	10/6
DRA duplex	10	8	3
P400	16	12	4
P500	20	15	3
RSIV	30	$12\frac{1}{4}$	3
P900	35	18	3
P1250	49	23	2
RS3V	72/47	25	$2\frac{1}{2}/1\frac{3}{4}$
P1800	72	$29\frac{1}{2}$	$1\frac{1}{3}$
P2500	100	$29\frac{1}{3}$	$1\frac{1}{3}$
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RS9K	$11\frac{1}{2}$	$28\frac{3}{4}$	$2\frac{1}{2}$
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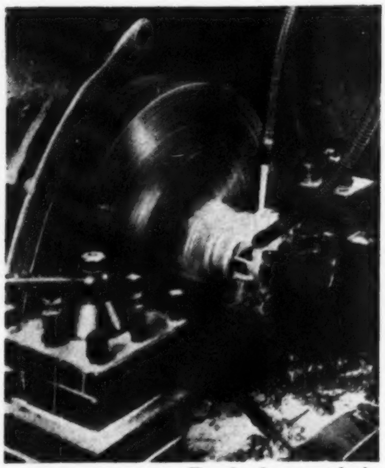

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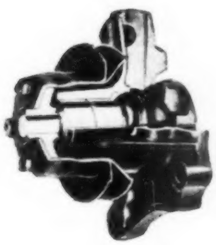

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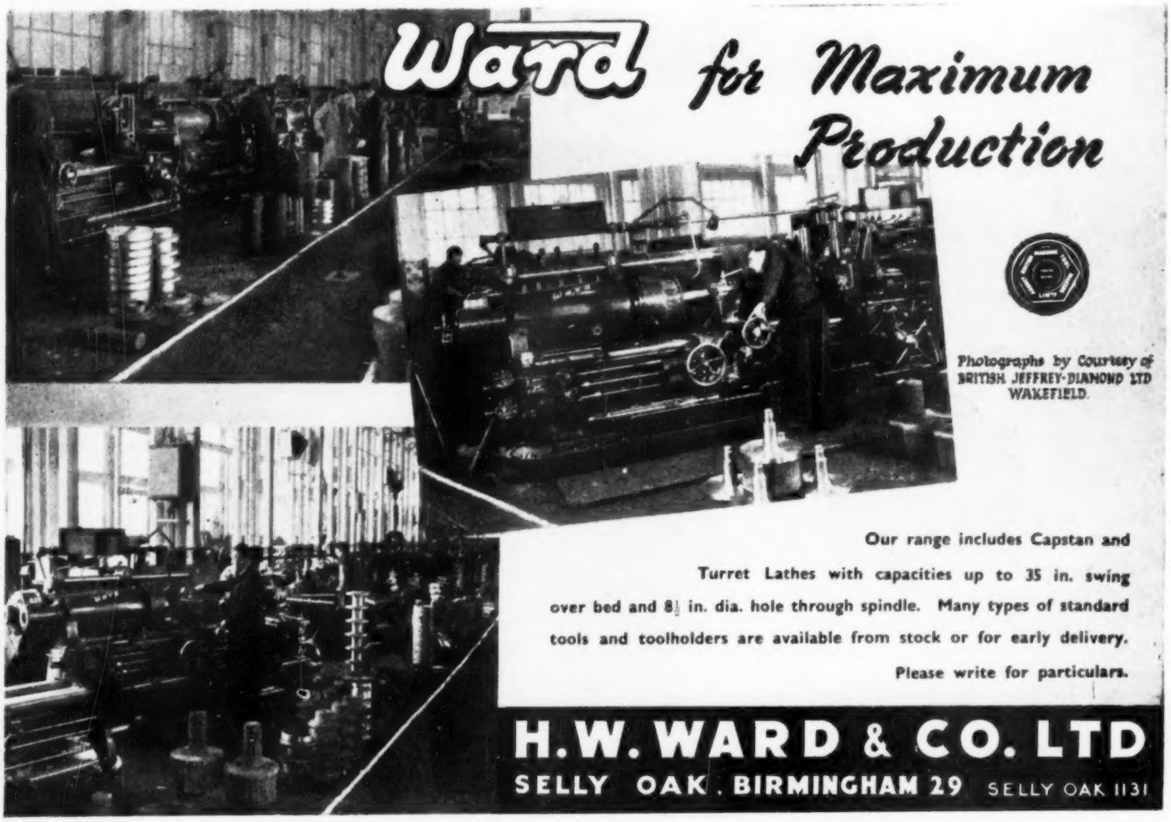
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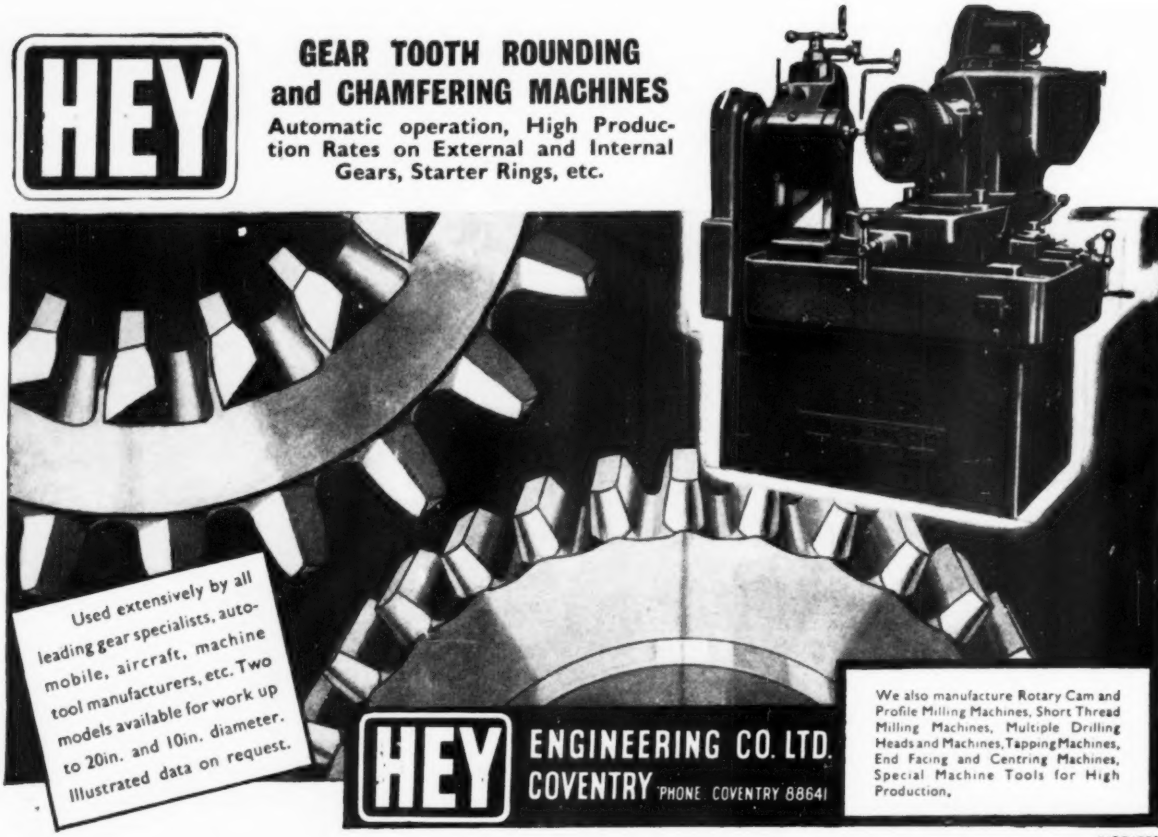

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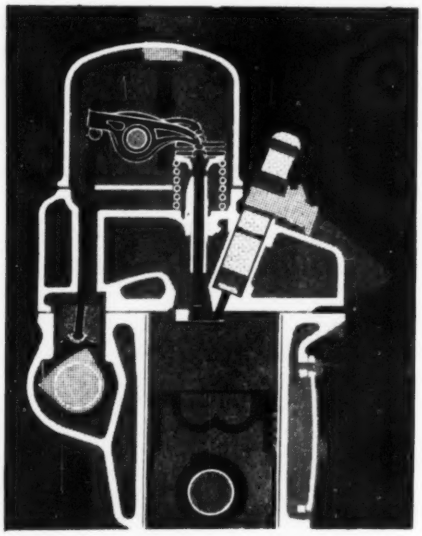

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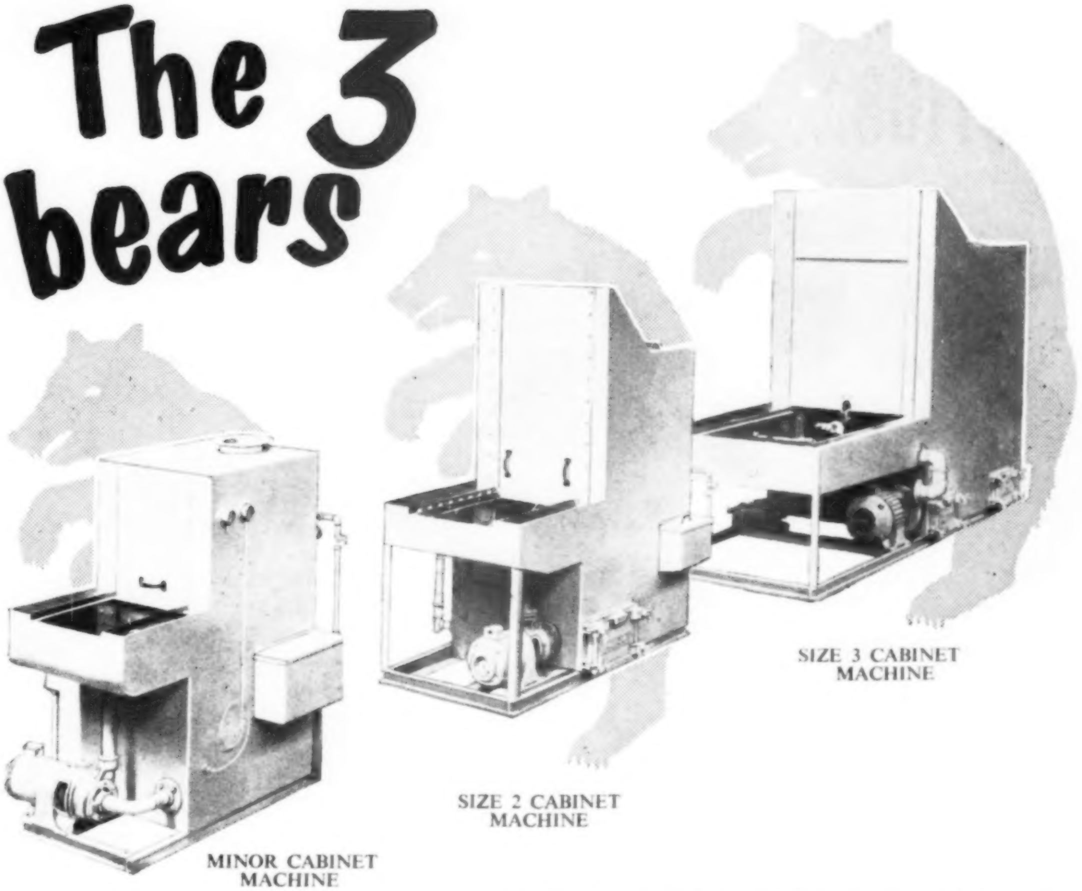

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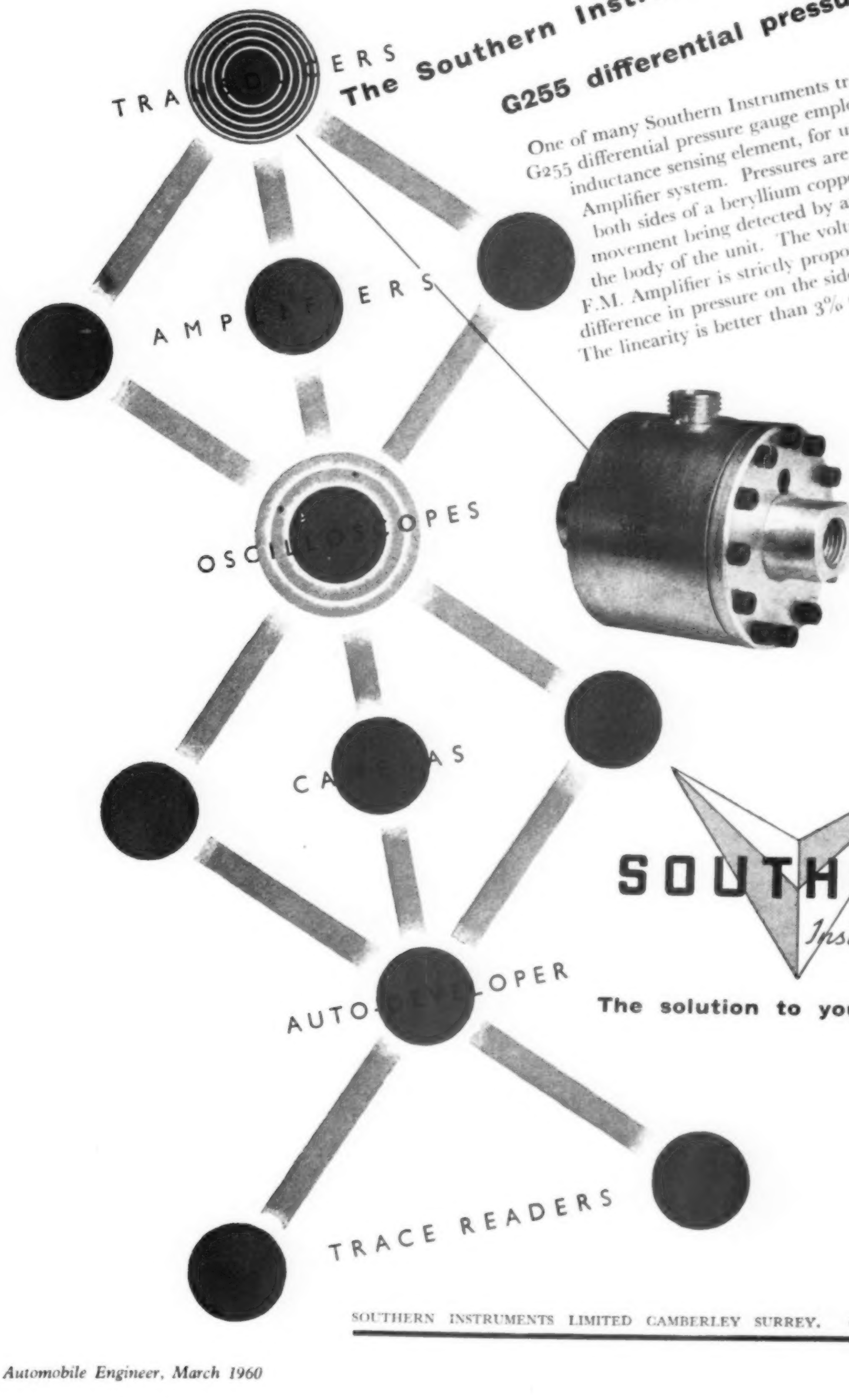

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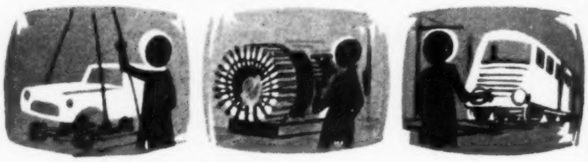

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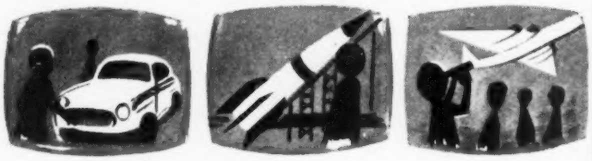

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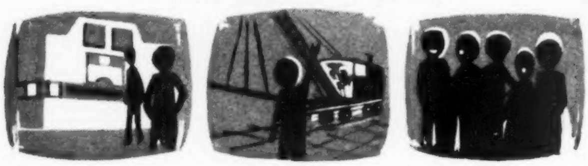

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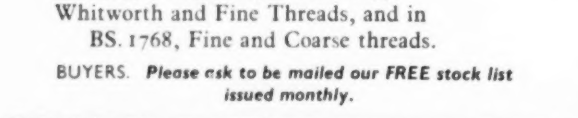

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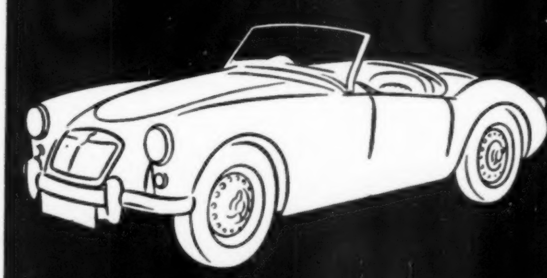

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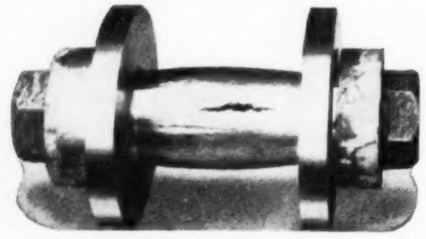

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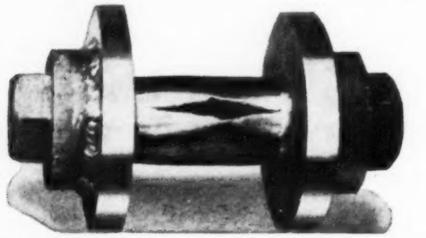

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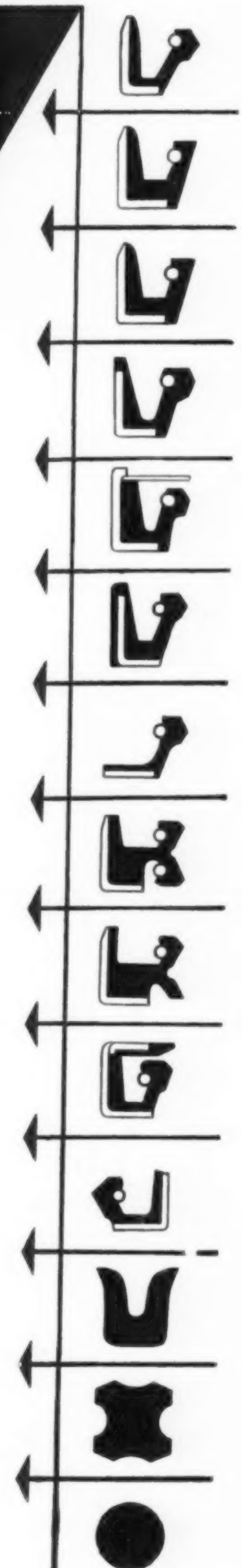

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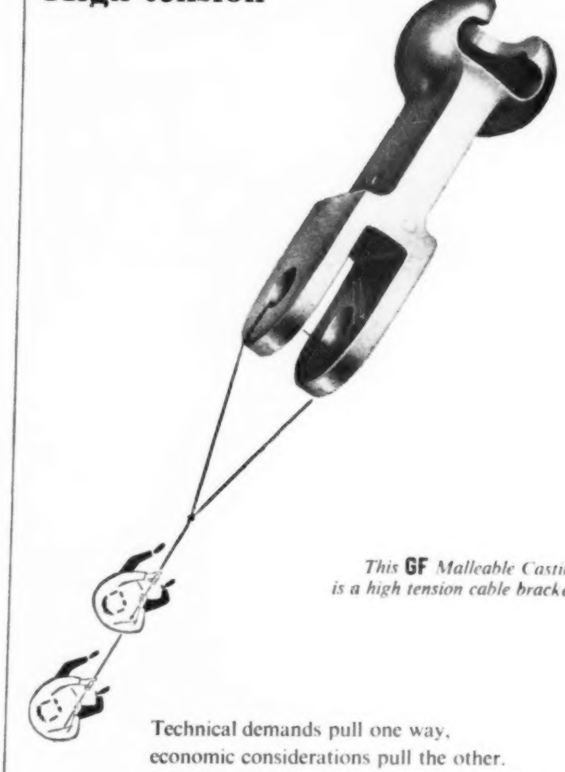

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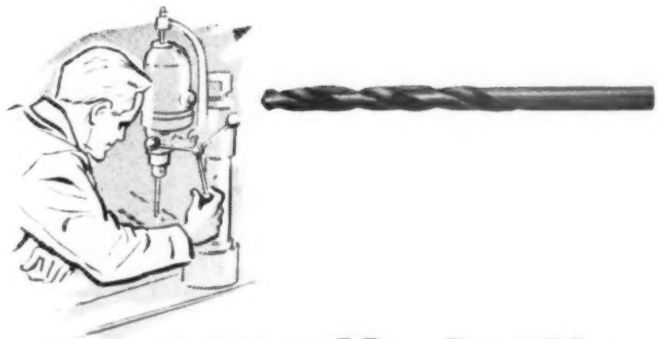

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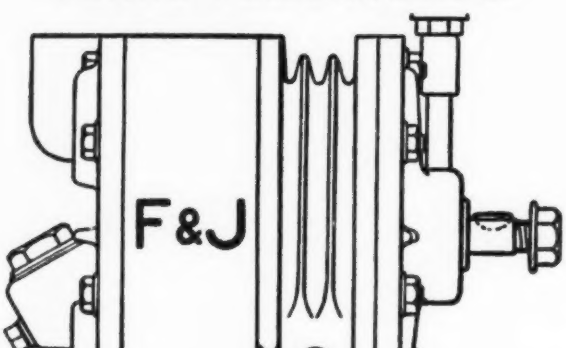

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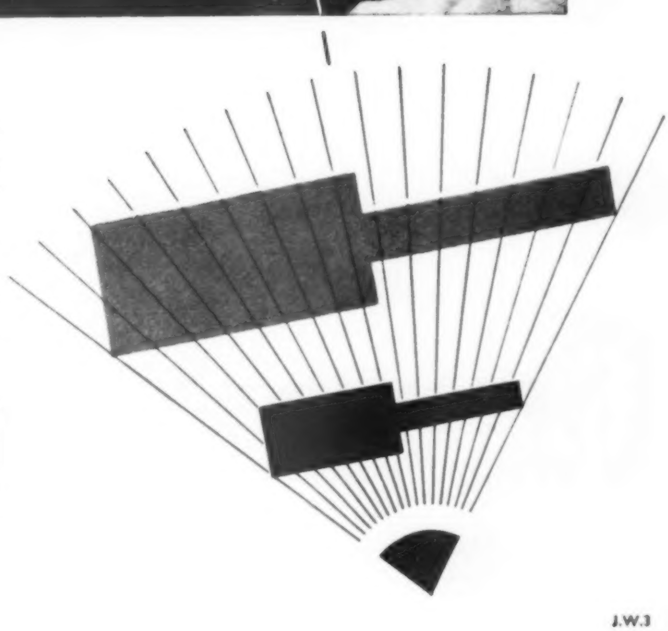

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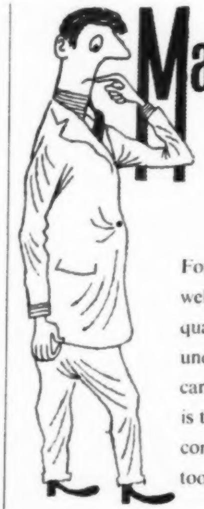

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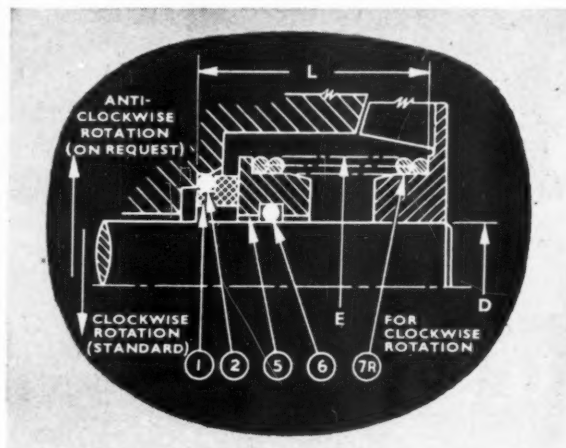

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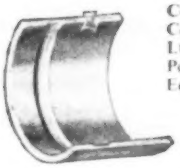

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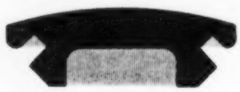

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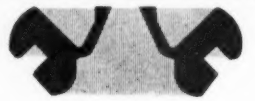

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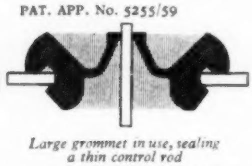

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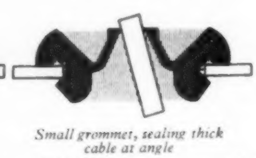

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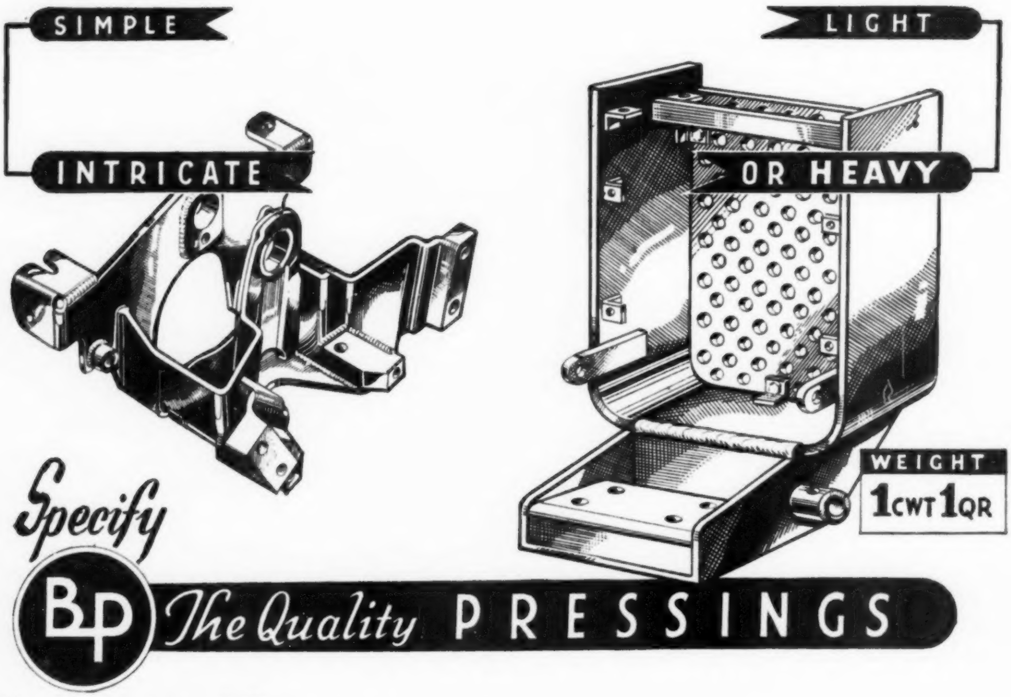

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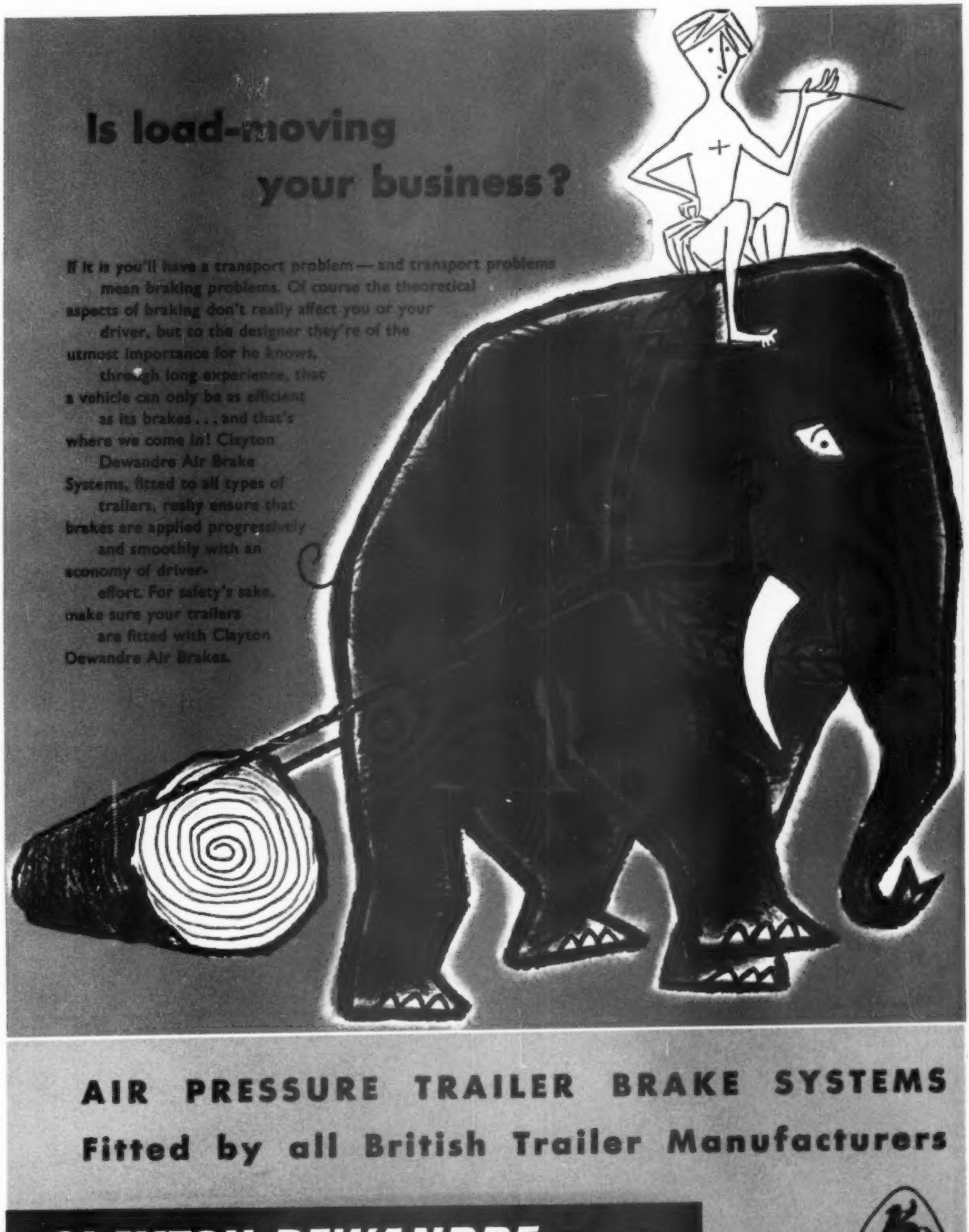
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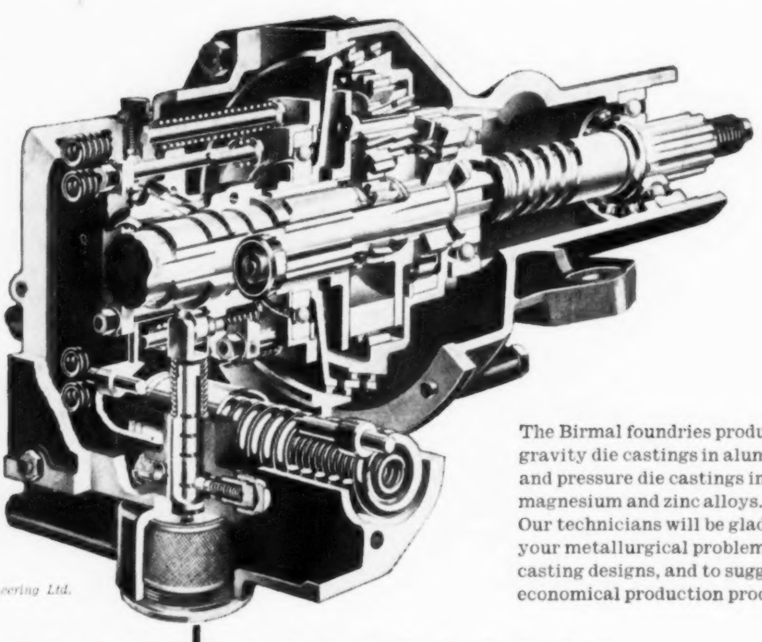

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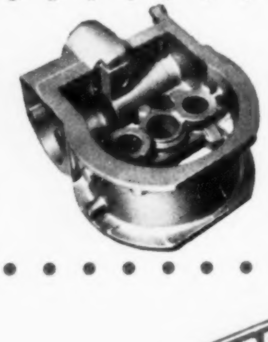

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